

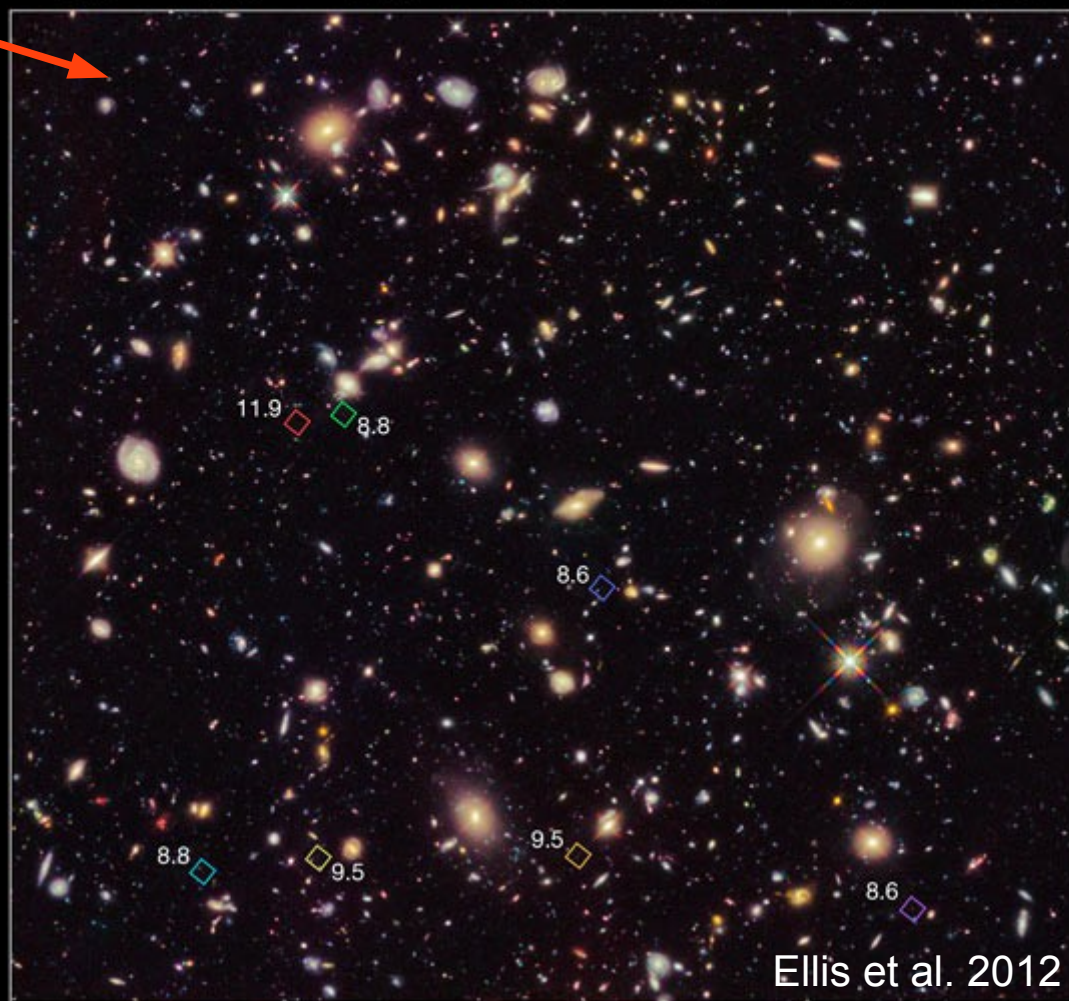
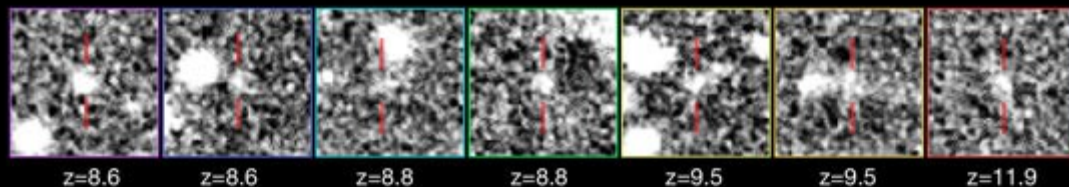
# Sledi oddaljenih galaksij v izbruhih sevanja gama

Jure Japelj

Fakulteta za matematiko in fiziko

# Galaksije

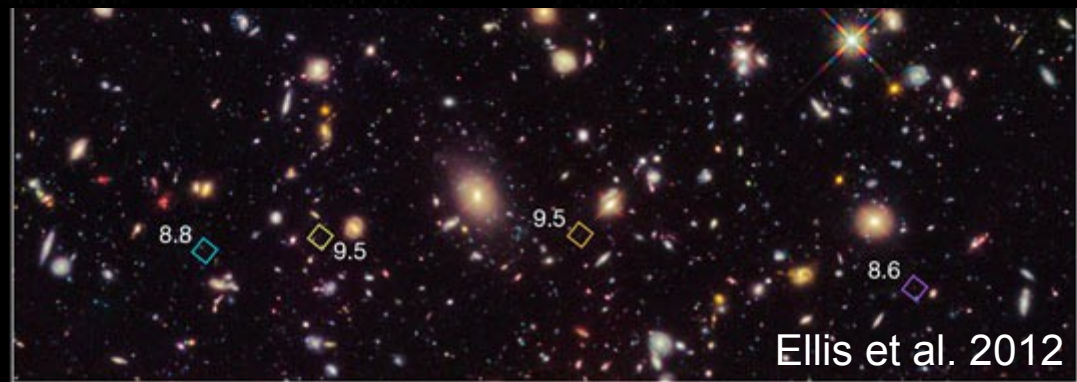
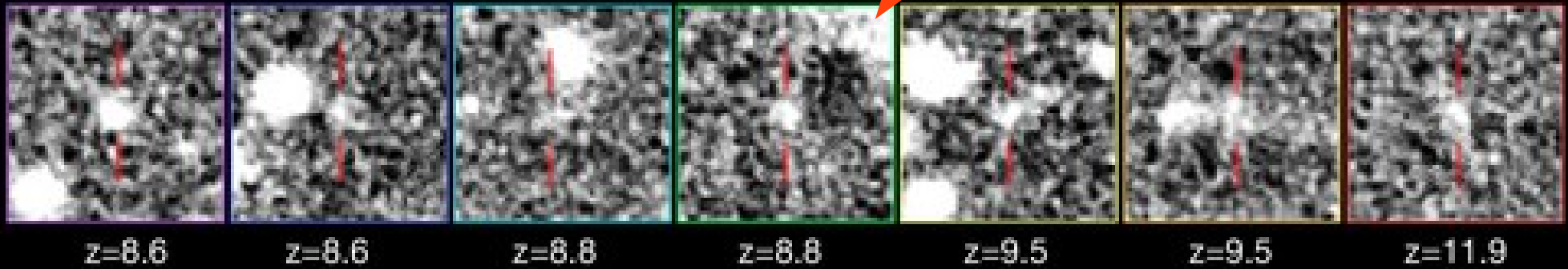
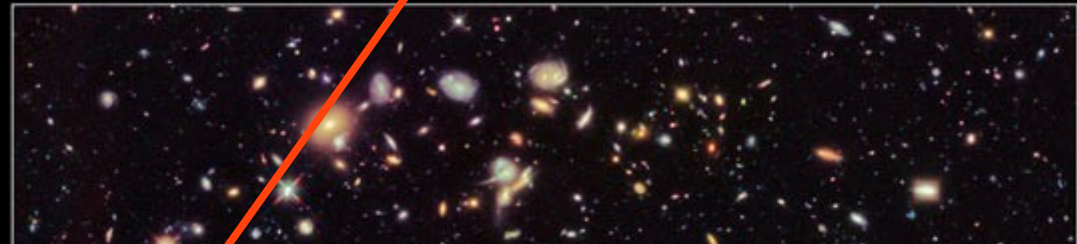
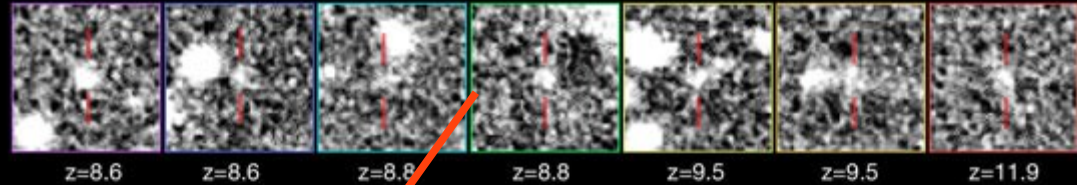
HST: v vesolju je  $>180$  milijard galaksij!



# Galaksije

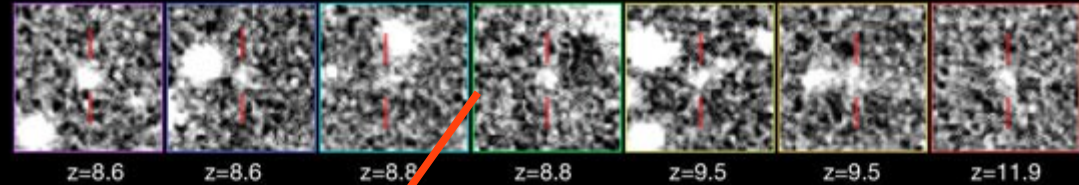
HST: v vesolju je  $>180$  milijard galaksij!

Najbolj oddaljene galaksije:

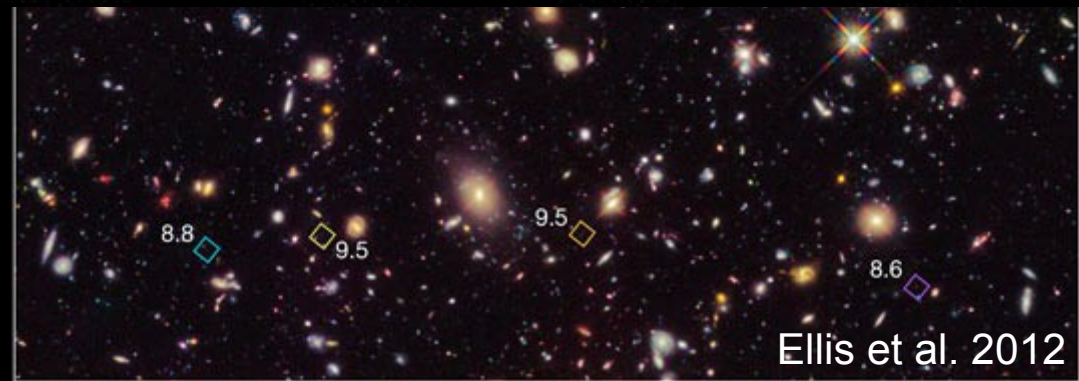
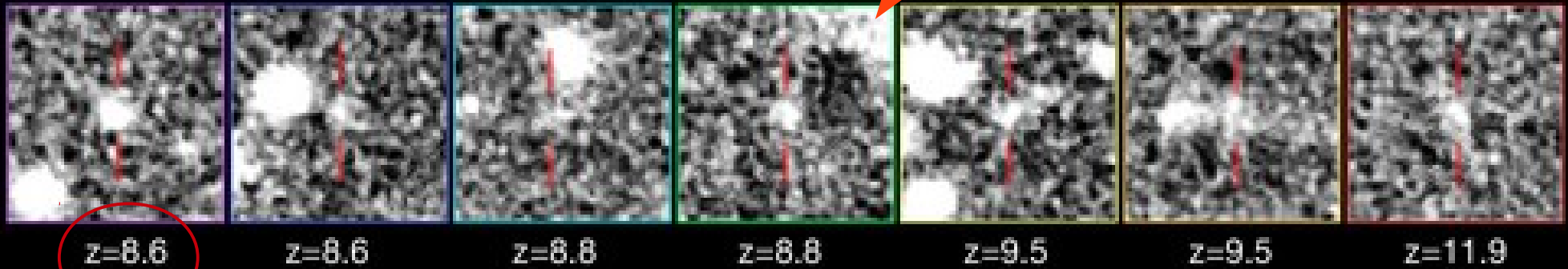


# Galaksije

HST: v vesolju je >180 milijard galaksij!



Najbolj oddaljene galaksije:



$$1 + z = \frac{R_0}{R} = \frac{\lambda_{op}}{\lambda_{em}}$$

# Galaksije

Lastnosti oddaljenih galaksij

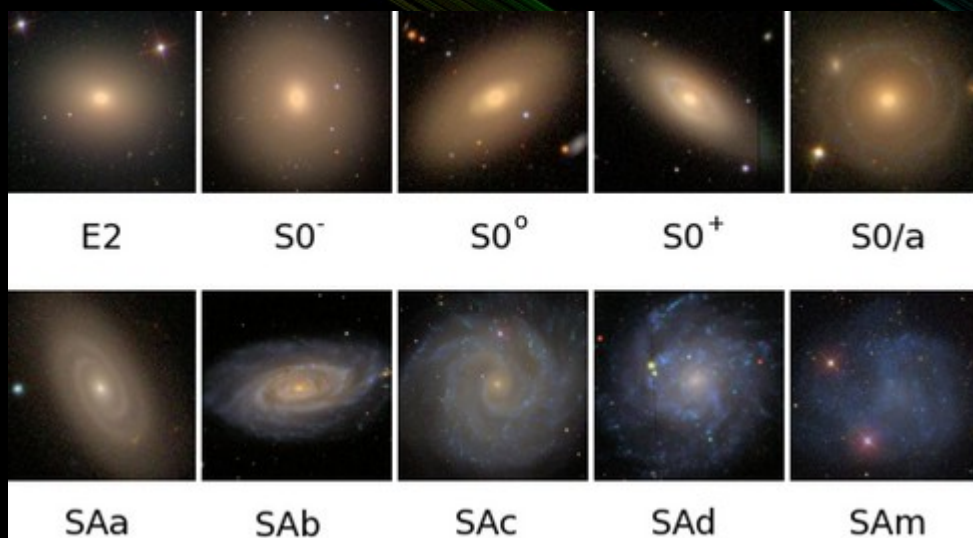
- se razlikujejo od lokalnih galaksij?
- kaj nas bi pravzaprav zanimalo?

# Galaksije

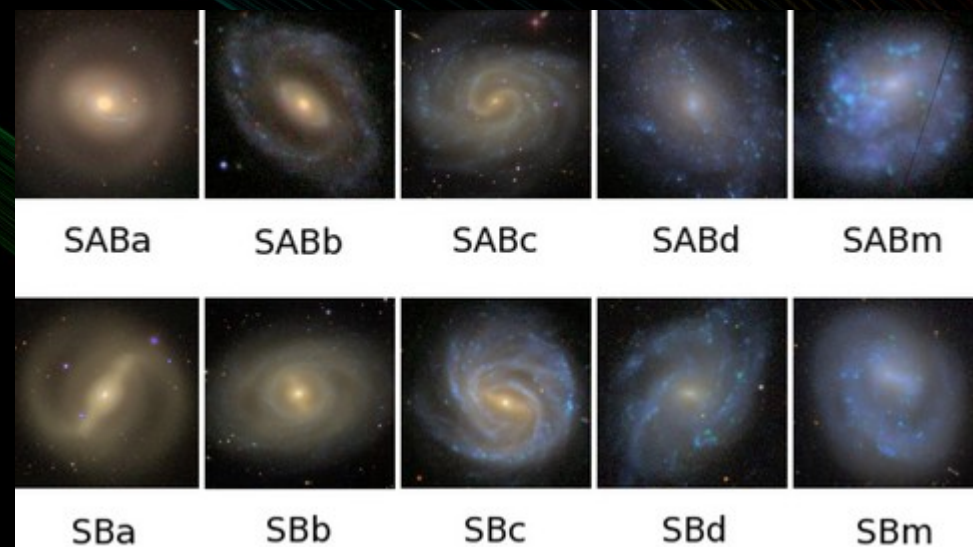
## Lastnosti oddaljenih galaksij

- se razlikujejo od lokalnih galaksij?
- kaj nas bi pravzaprav zanimalo?

## Morfologija?



HST, JWST, ...



# Galaksije

## Lastnosti oddaljenih galaksij

- se razlikujejo od lokalnih galaksij?
- kaj nas bi pravzaprav zanimalo?

Hitrost nastajanja zvezd, količina in lastnost prahu v galaksiji, kovinskost, masa, ...

# Galaksije

## Lastnosti oddaljenih galaksij

- se razlikujejo od lokalnih galaksij?
- kaj nas bi pravzaprav zanimalo?

**Hitrost nastajanja zvezd**, količina in lastnost prahu v galaksiji, kovinskost, masa ...



~ 1 masa Sonca na leto za našo galaksijo

~ 10-100 mas Sonca na leto za 'Lyman-break' galaksije, 'starburst' galaksije

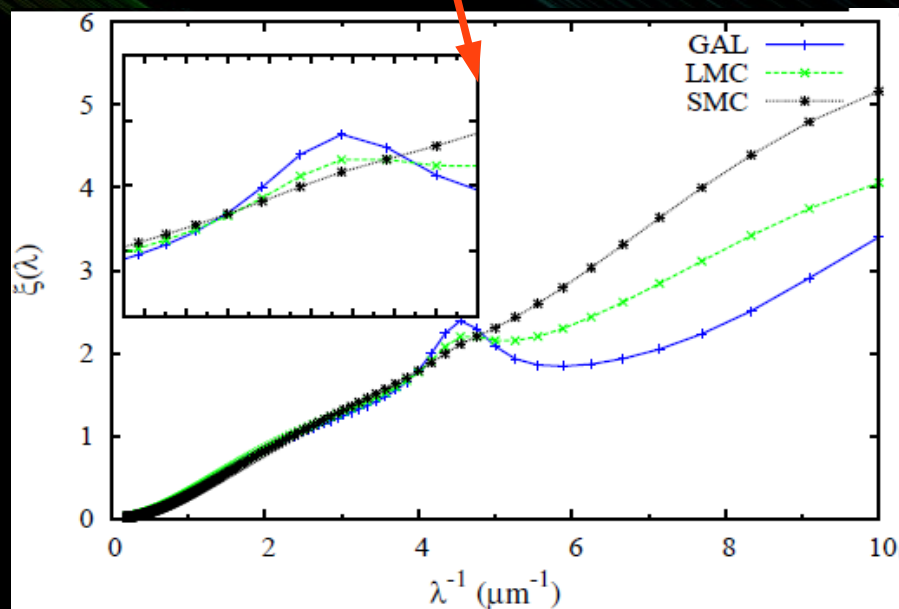


# Galaksije

## Lastnosti oddaljenih galaksij

- se razlikujejo od lokalnih galaksij?
- kaj nas bi pravzaprav zanimalo?

Hitrost nastajanja zvezd, **količina in lastnost prahu** v galaksiji, kovinskost, masa, ...

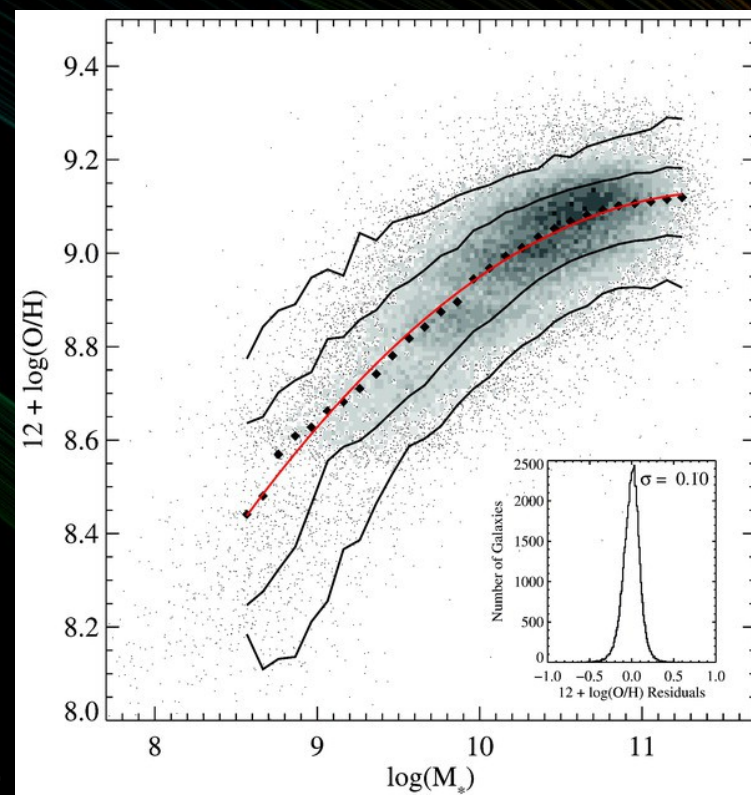
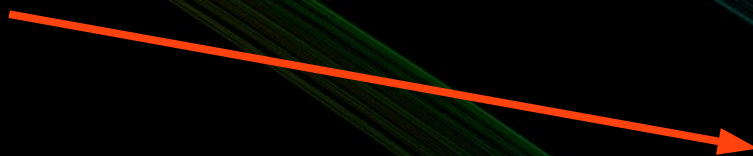


# Galaksije

## Lastnosti oddaljenih galaksij

- se razlikujejo od lokalnih galaksij?
- kaj nas bi pravzaprav zanimalo?

Hitrost nastajanja zvezd, količina in lastnost prahu v galaksiji,  
**kovinskost, masa, ...**



# Galaksije

## Lastnosti oddaljenih galaksij

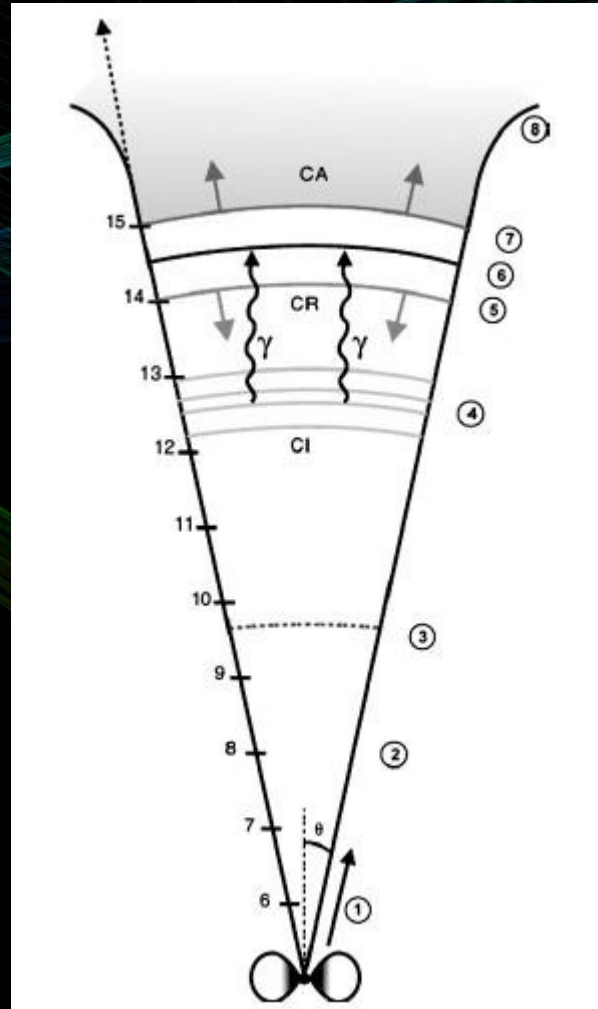
- se razlikujejo od lokalnih galaksij?
- kaj nas bi pravzaprav zanimalo?

Hitrost nastajanja zvezd, količina in lastnost prahu v galaksiji, kovinskost, masa, ...

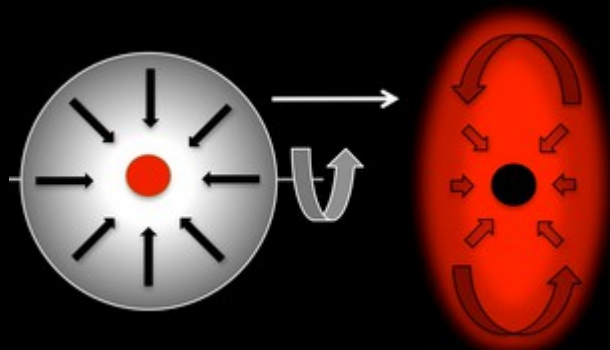
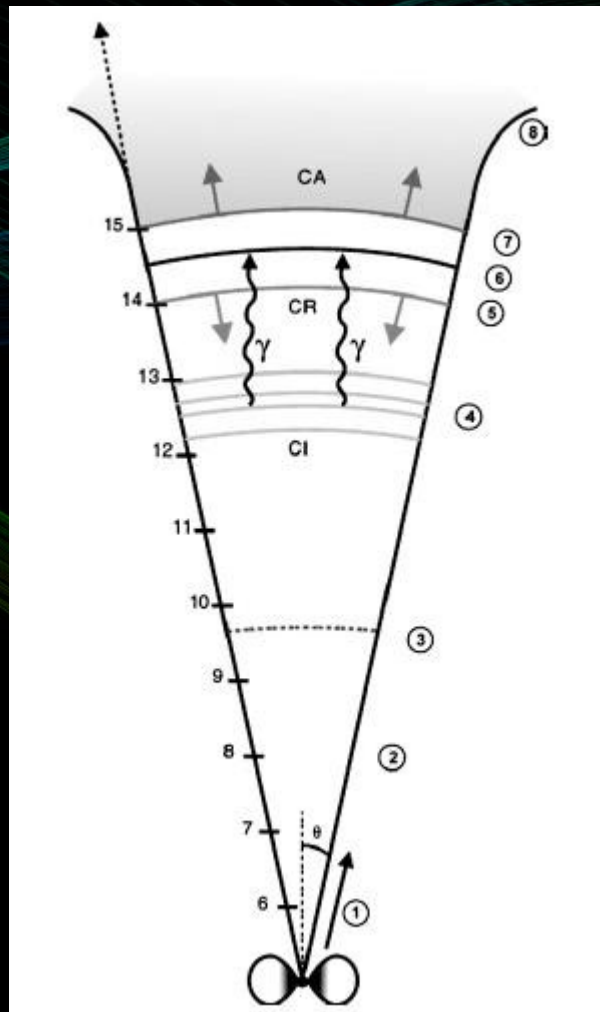
Idealno: spektroskopija + fotometrija

Težave s spektroskopijo zelo oddaljenih galaksij! Kot alternativni način lahko uporabimo zasije izbruhov sevanja gama!

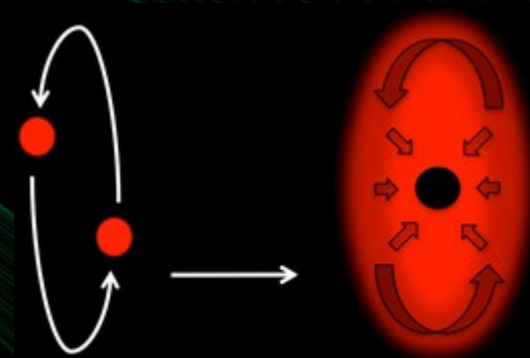
# Izbruhi sevanja gama in zasij



# Izbruhi sevanja gama in zasij

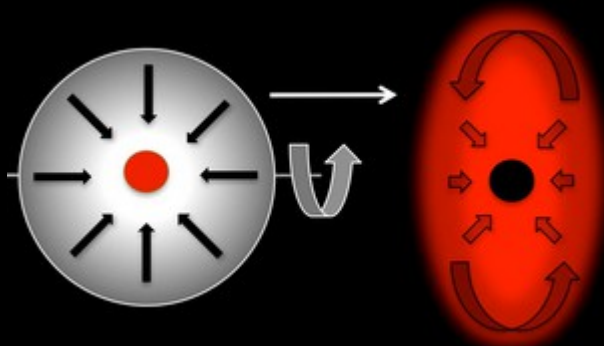
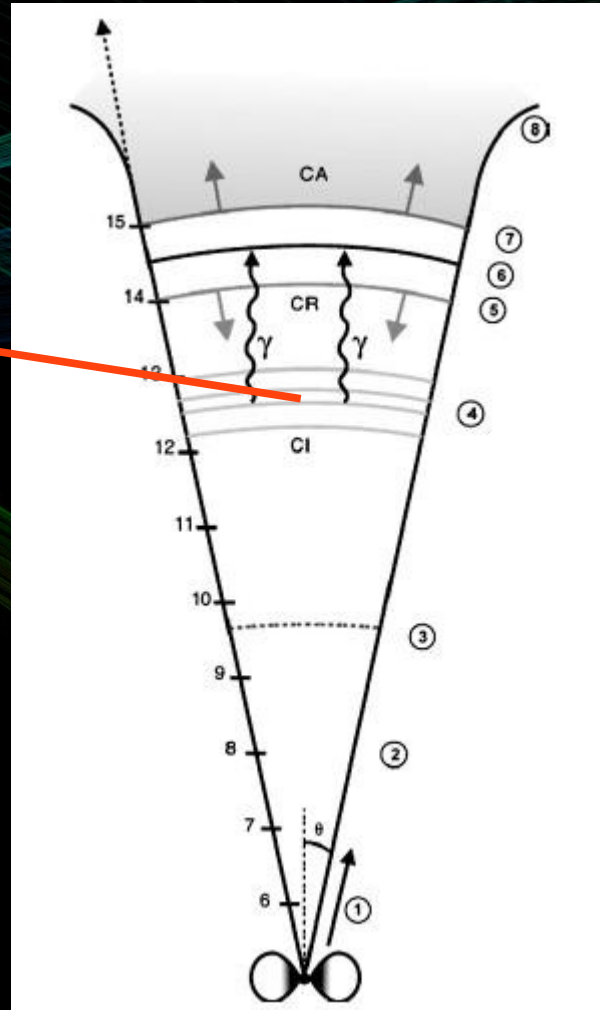
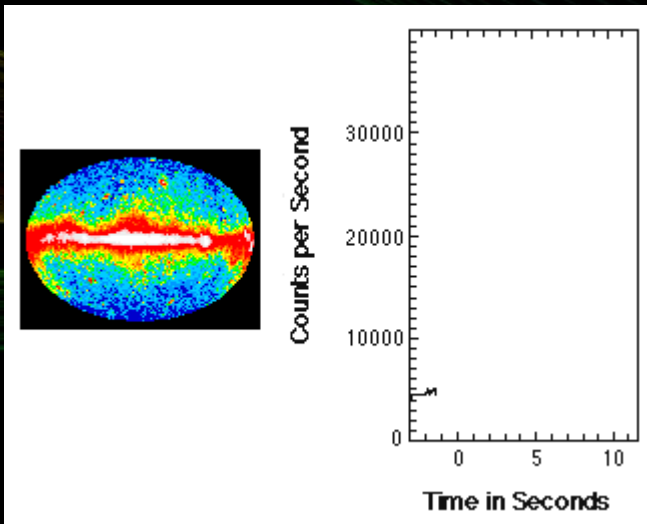


Dolgi izbruhi

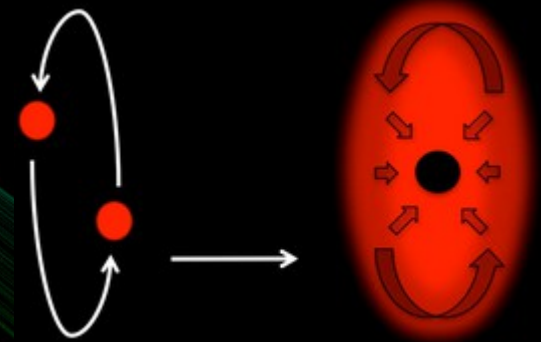


Kratki izbruhi

# Izbruhi sevanja gama in zasij

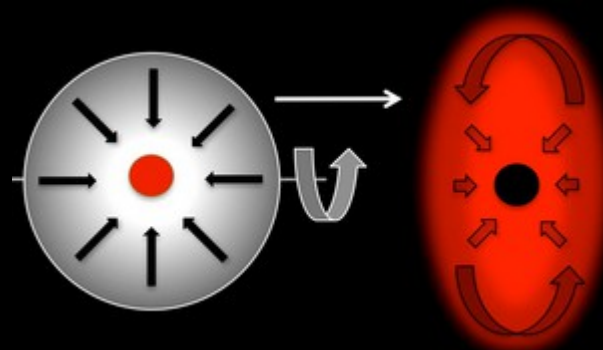
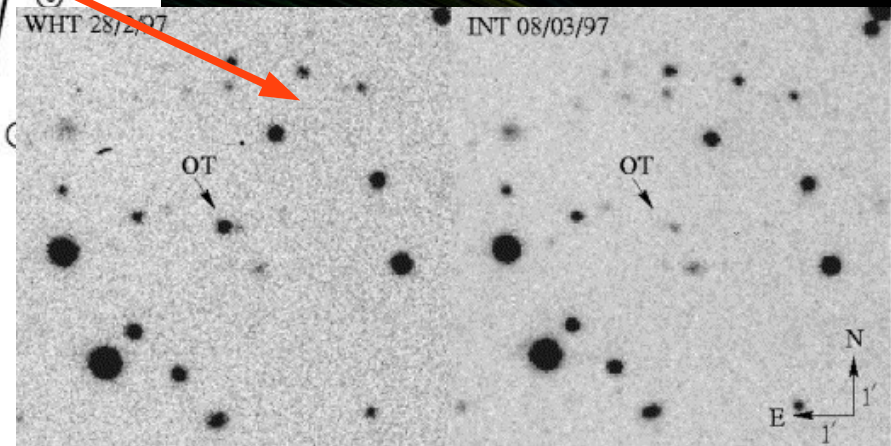
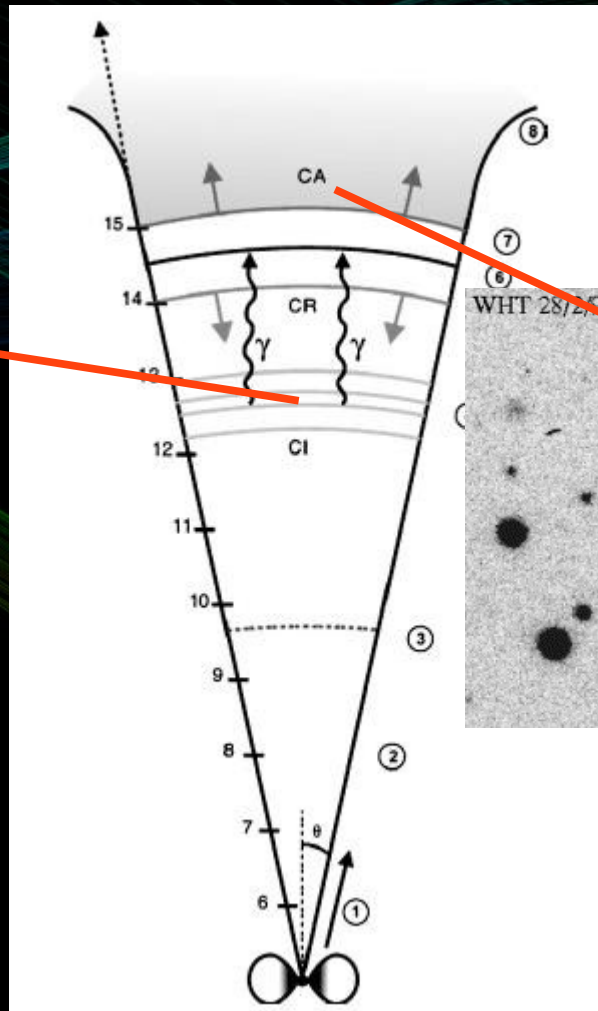
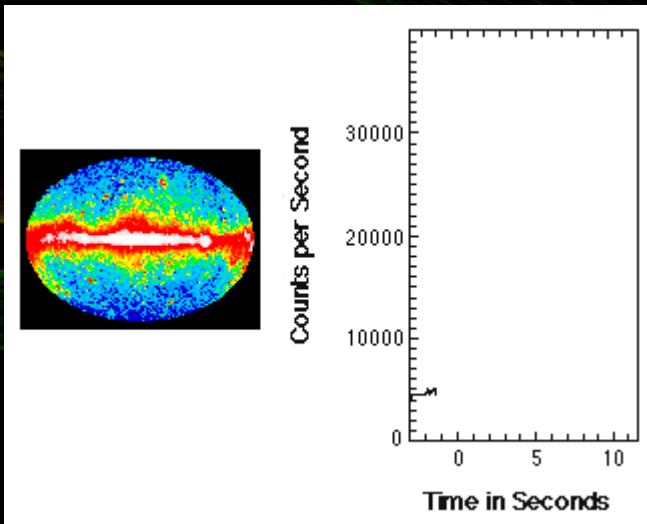


Dolgi izbruhi

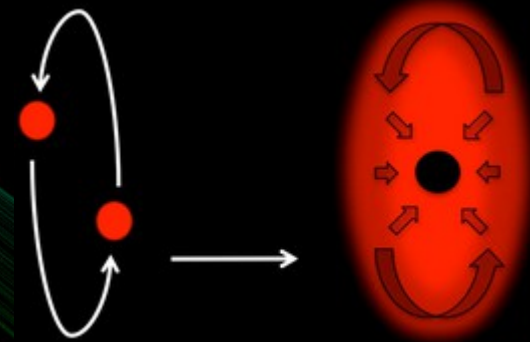


Kratki izbruhi

# Izbruhi sevanja gama in zasij

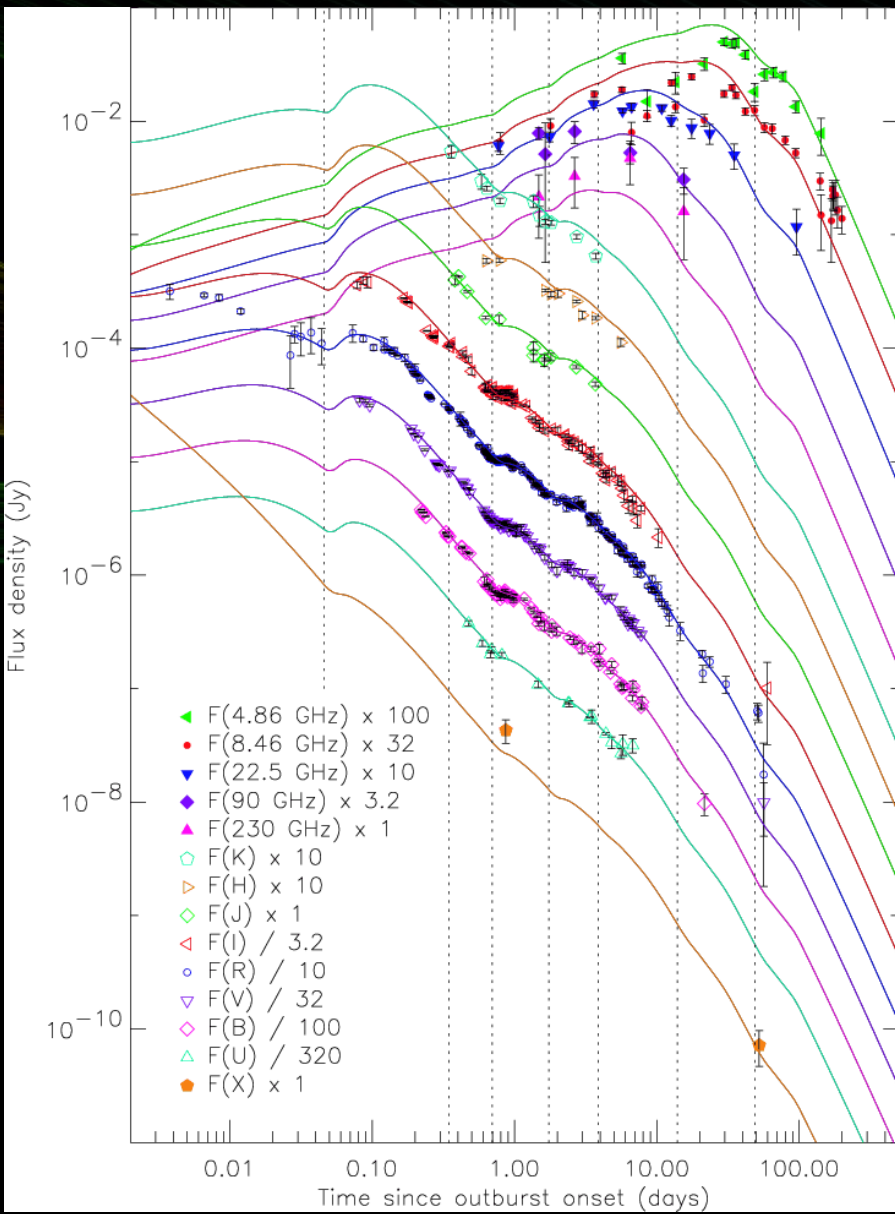


Dolgi izbruhi

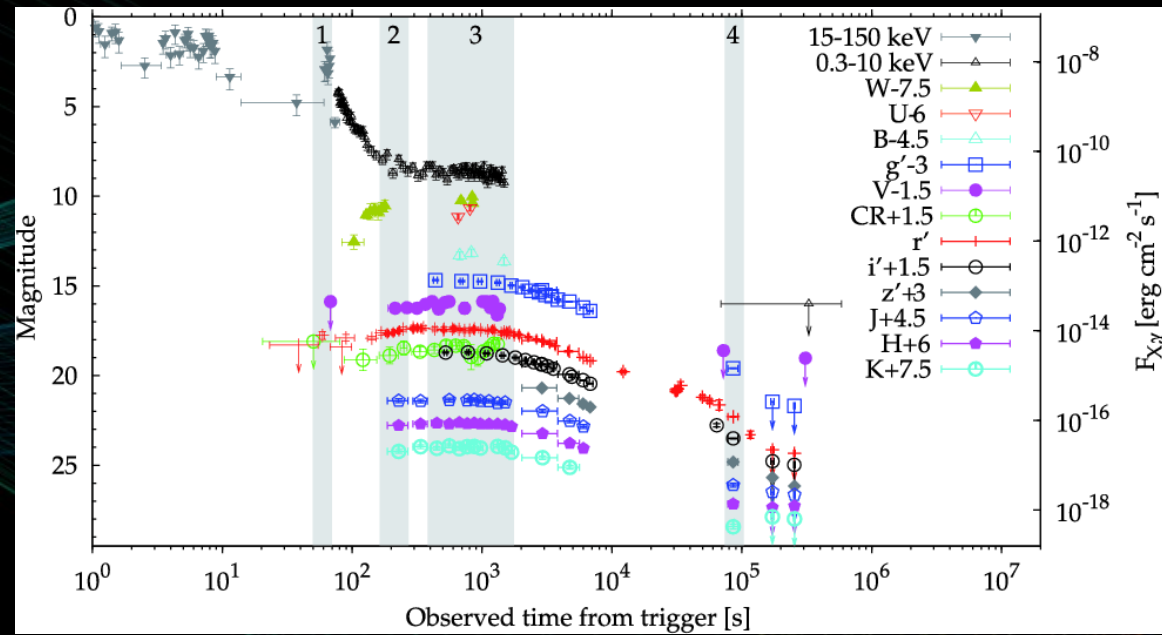


Kratki izbruhi

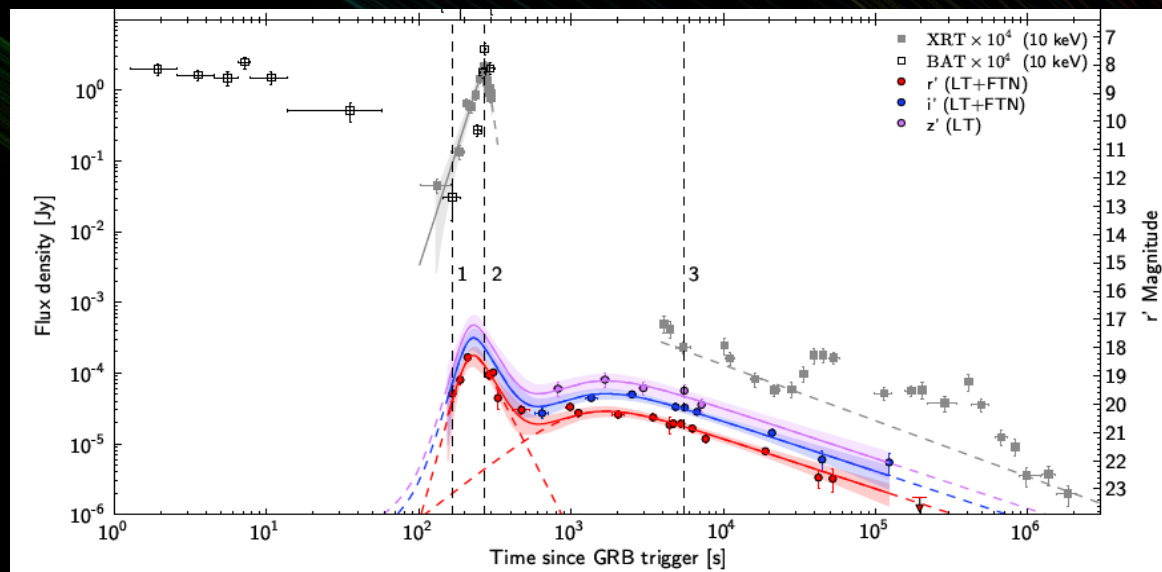
# Zasij – pestro obnašanje



de Ugarte Postigo et al. 2005



Guidorzi et al. 2009

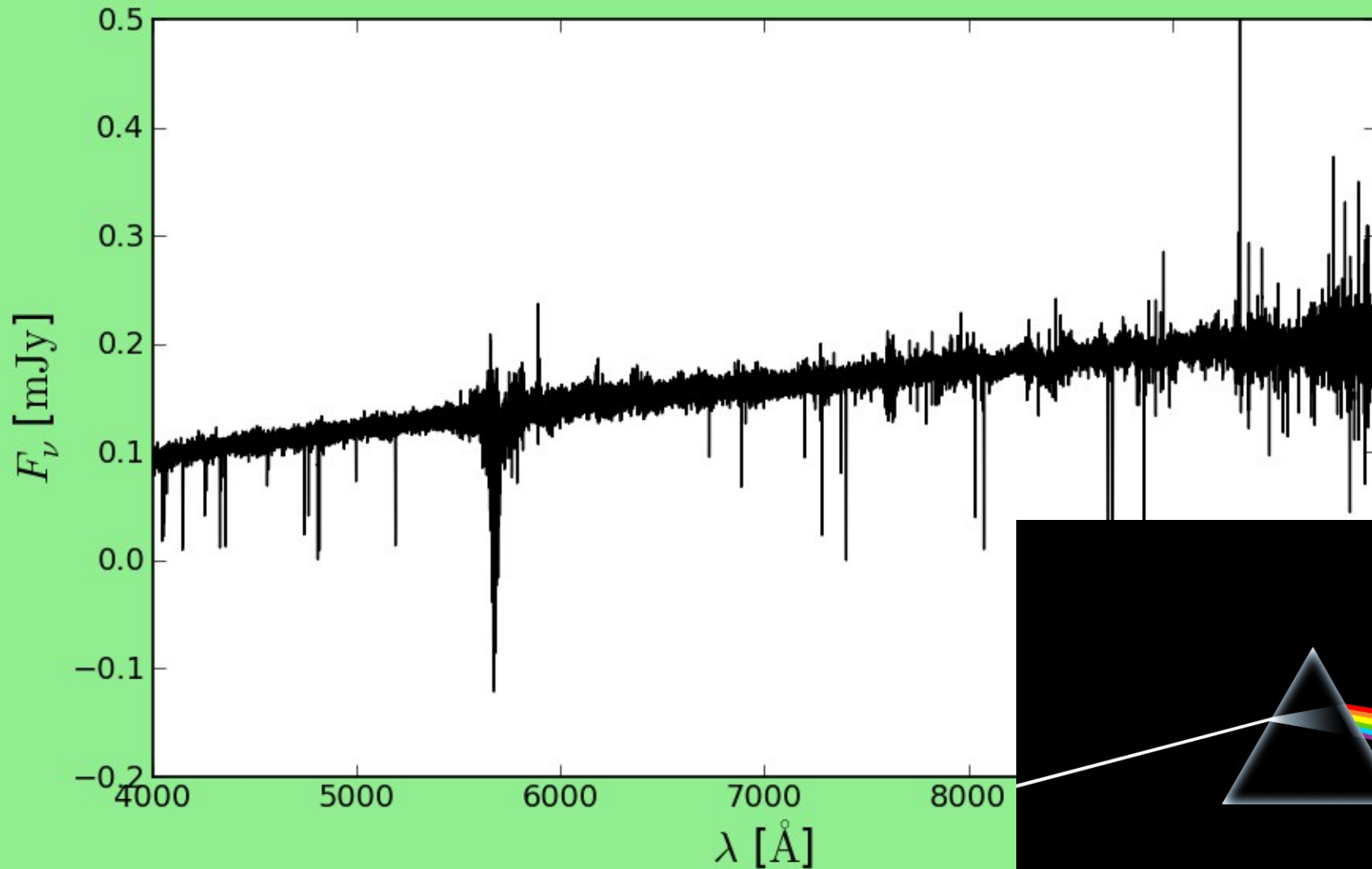


Kopač et al. 2013



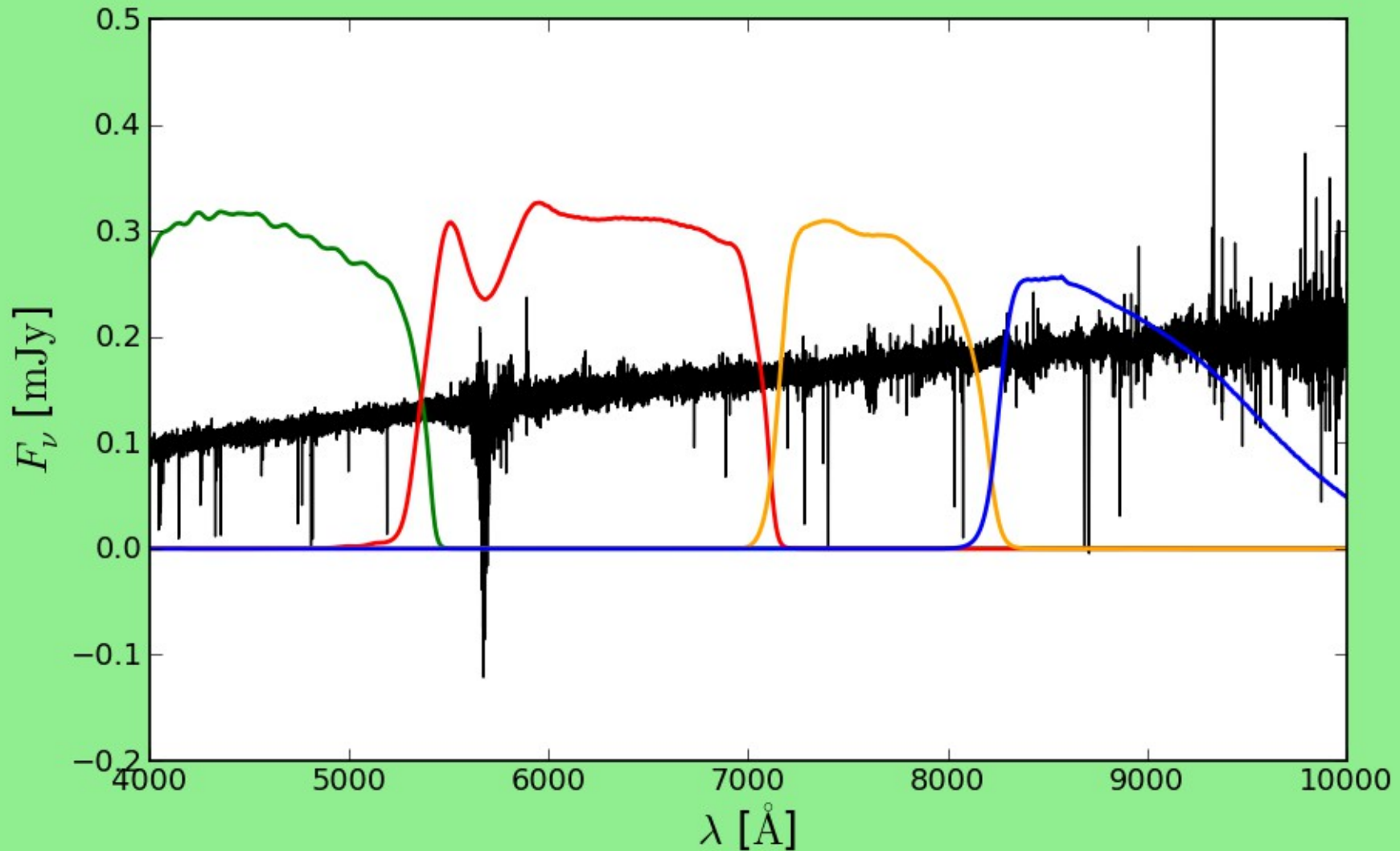
# Intermezzo: opazovalni tehniki

## Spektroskopija vs fotometrija



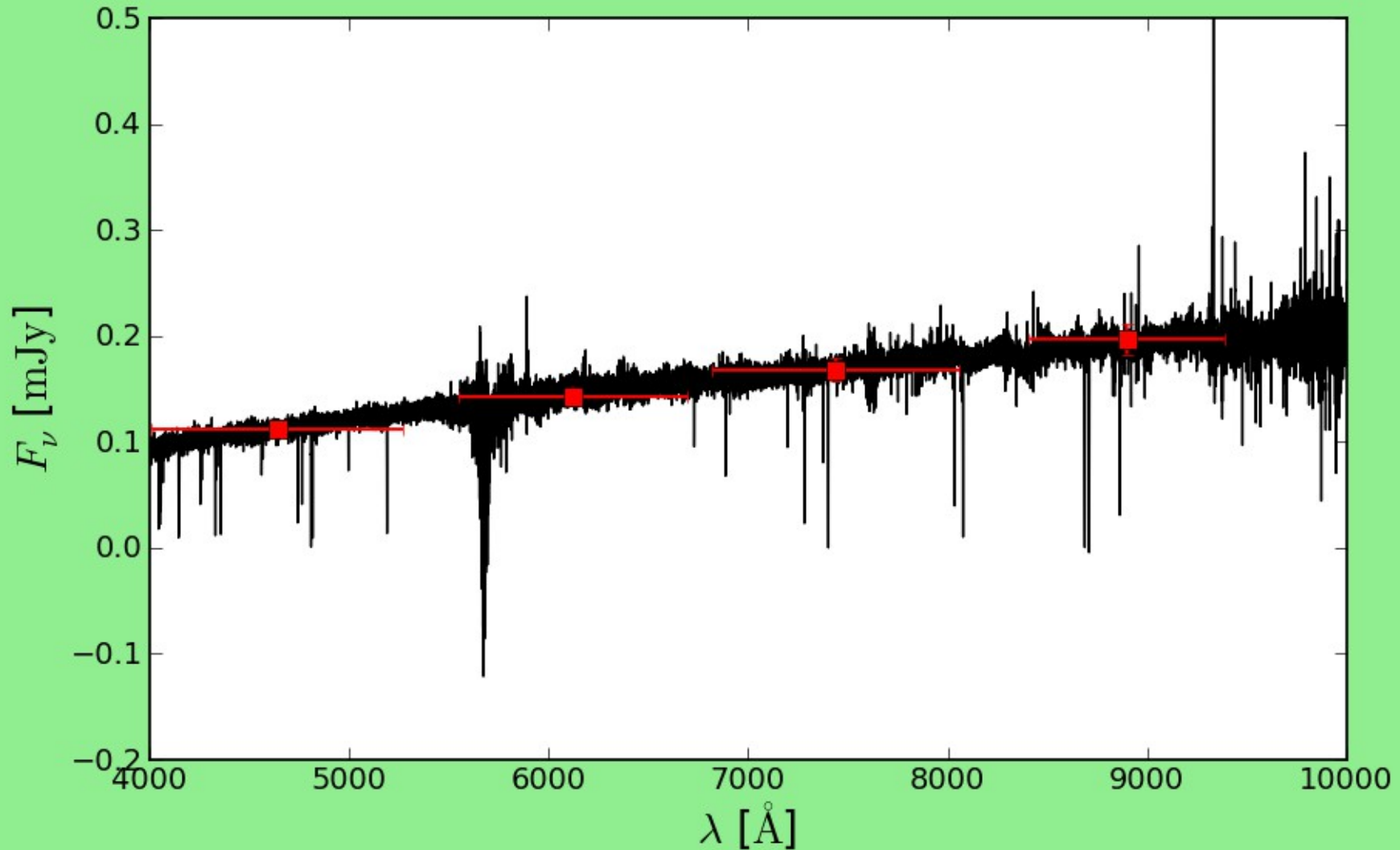
# Intermezzo: opazovalni tehniki

## Spektroskopija vs fotometrija



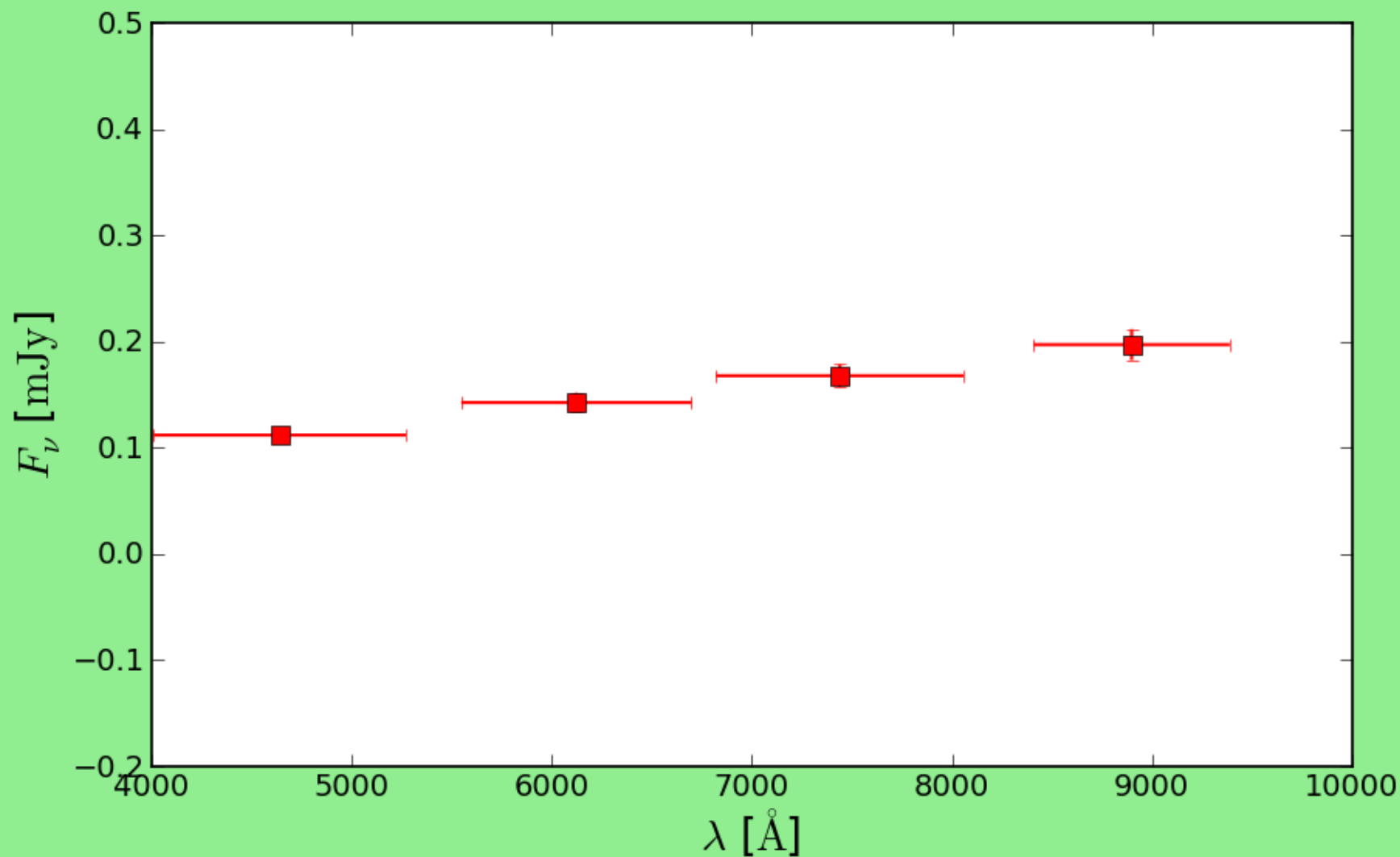
# Intermezzo: opazovalni tehniki

## Spektroskopija vs fotometrija



# Intermezzo: opazovalni tehniki

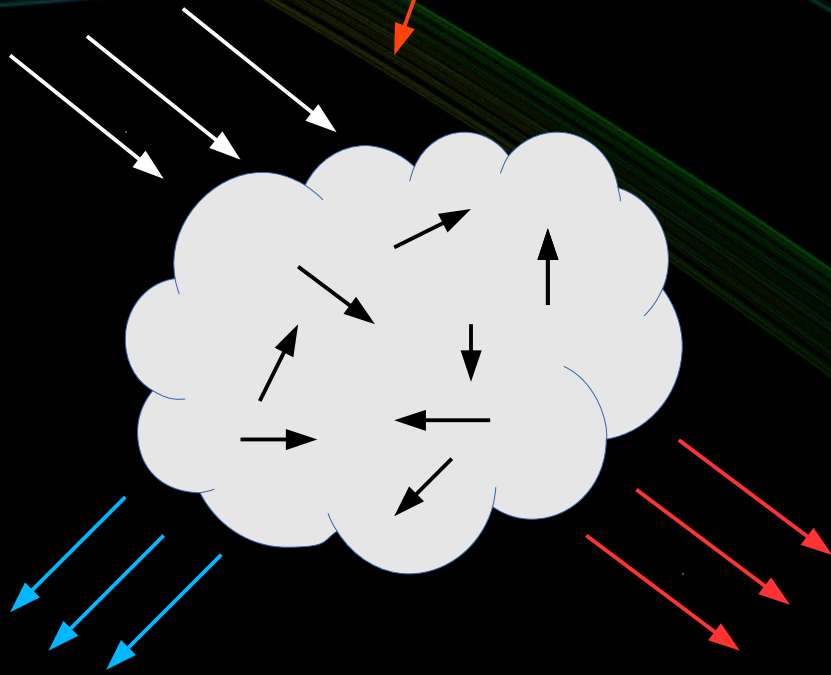
## Spektroskopija vs fotometrija



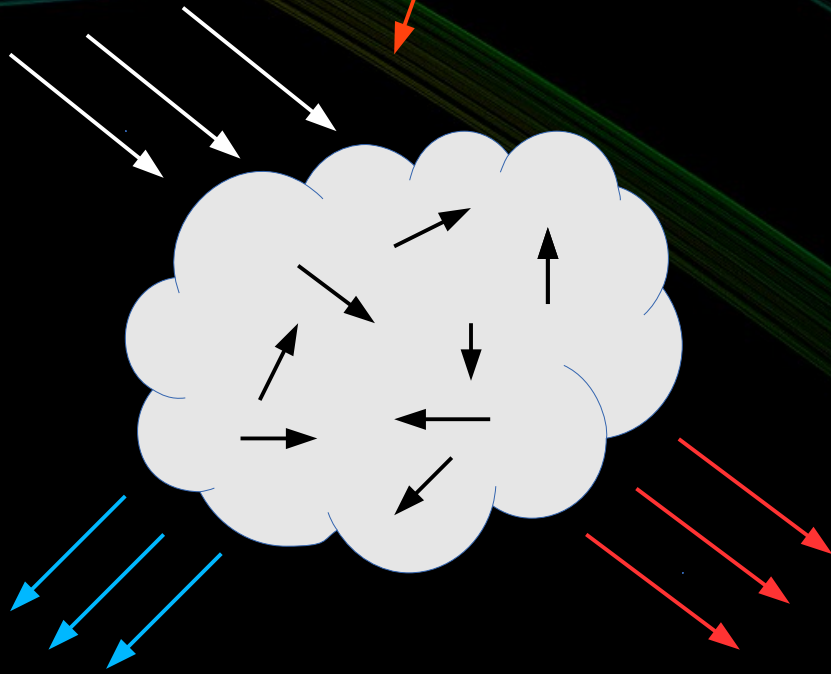
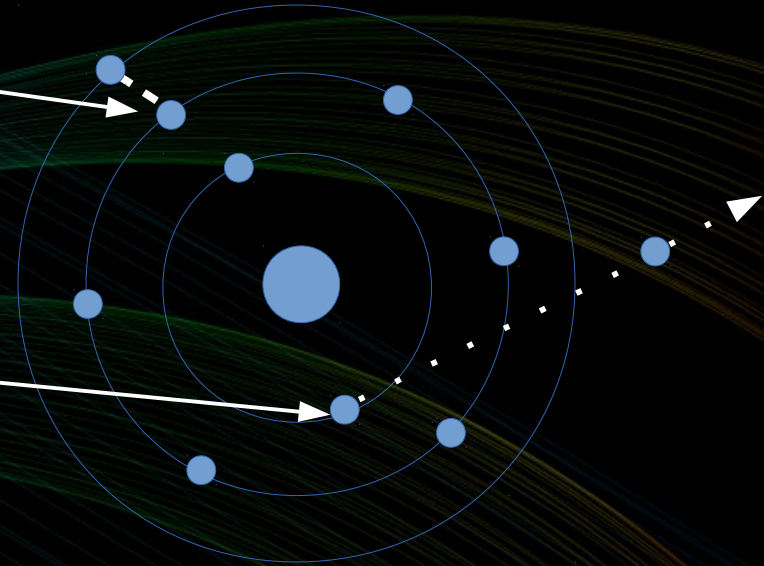
# Prve sledi galaksije gostiteljice



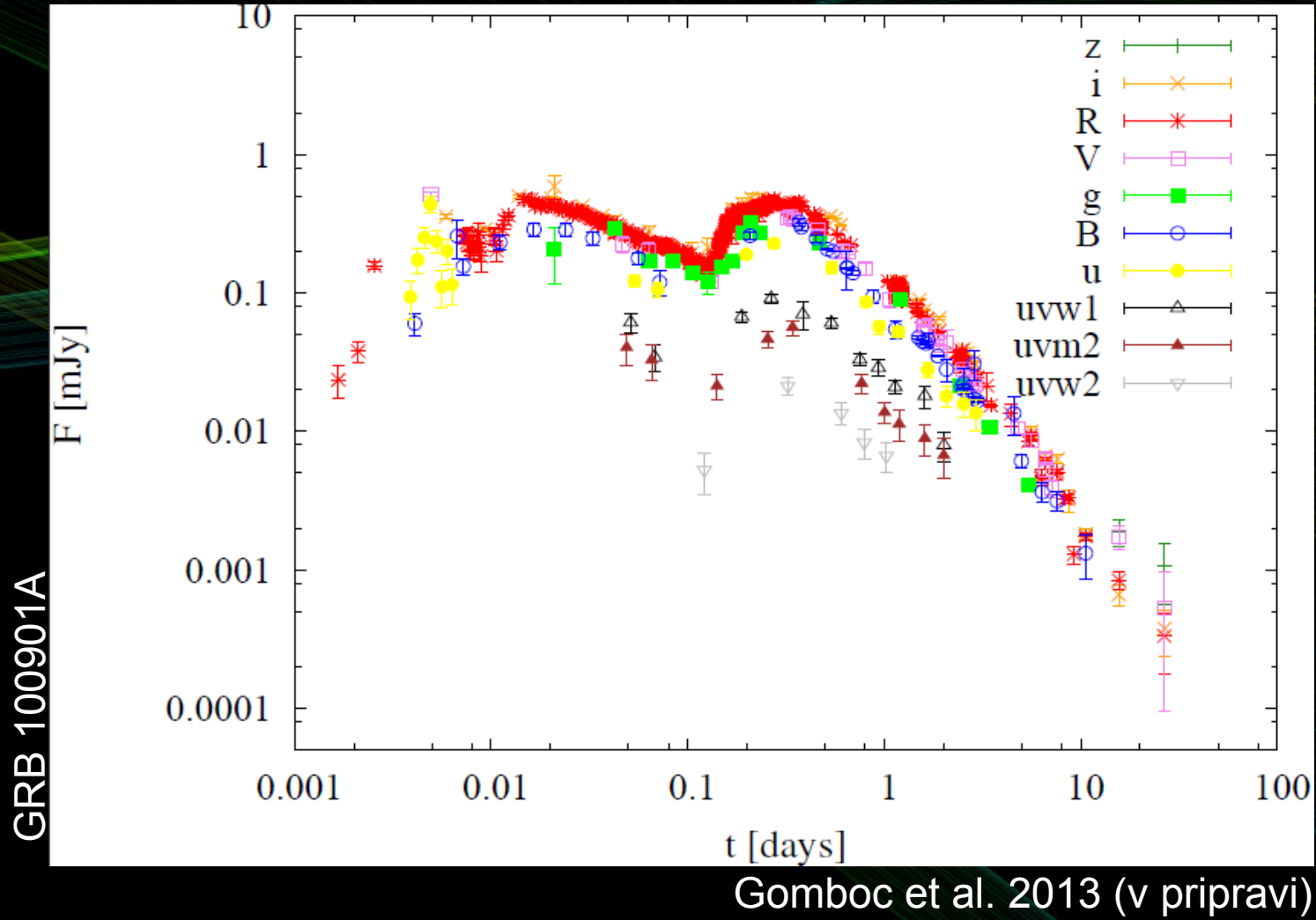
# Prve sledi galaksije gostiteljice



# Prve sledi galaksije gostiteljice

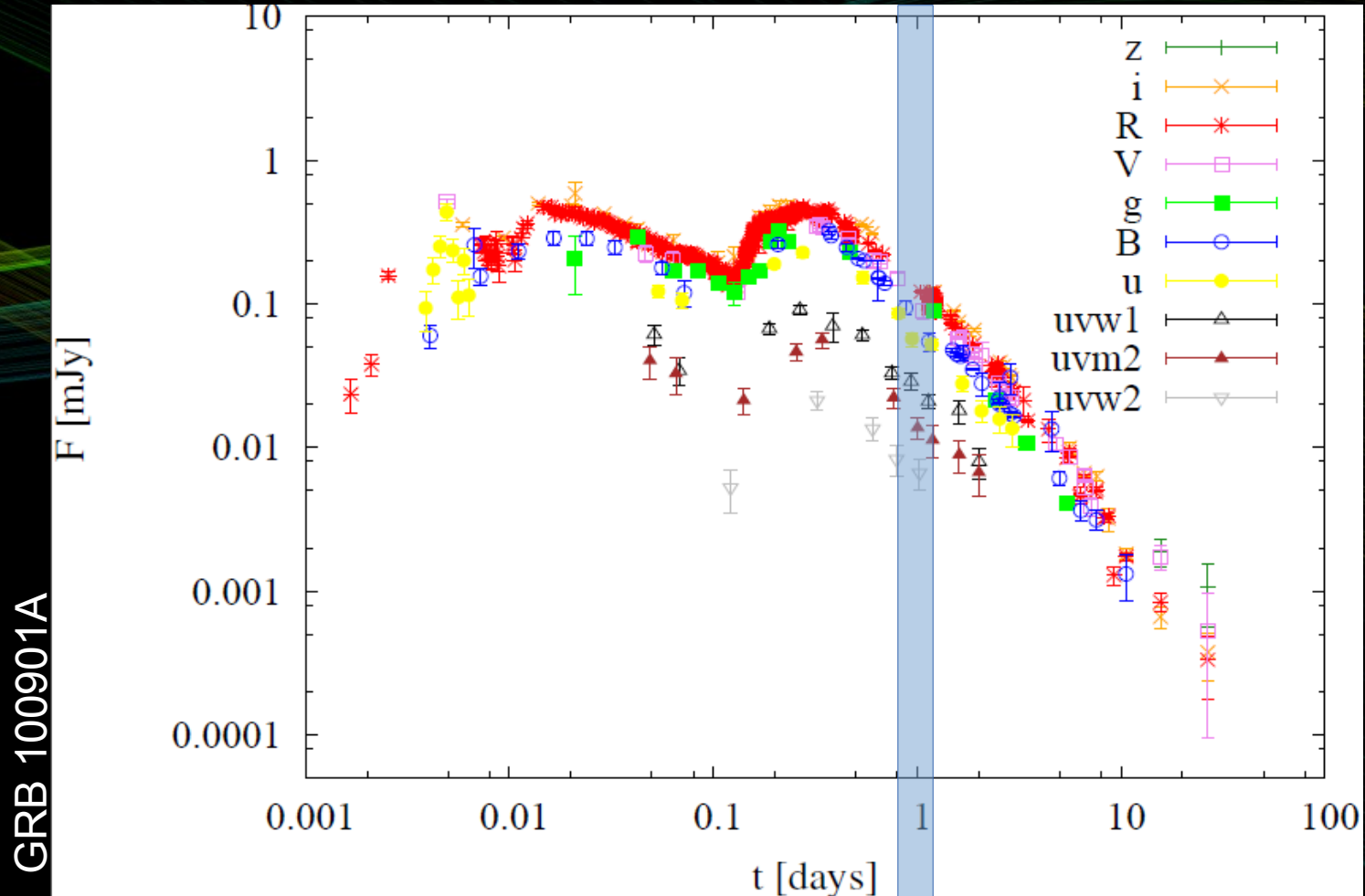


# Prve sledi galaksije gostiteljice



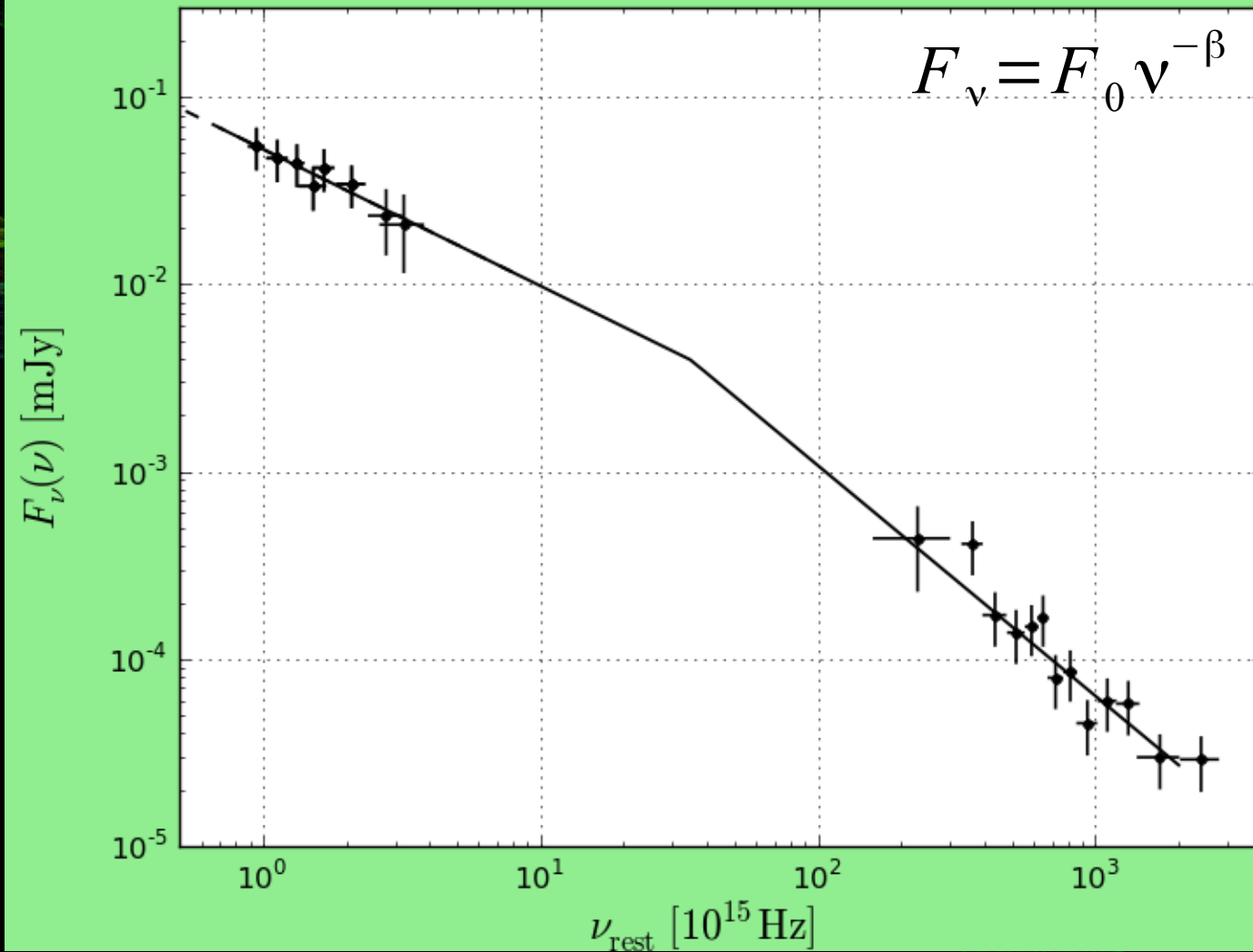


# Prve sledi galaksije gostiteljice

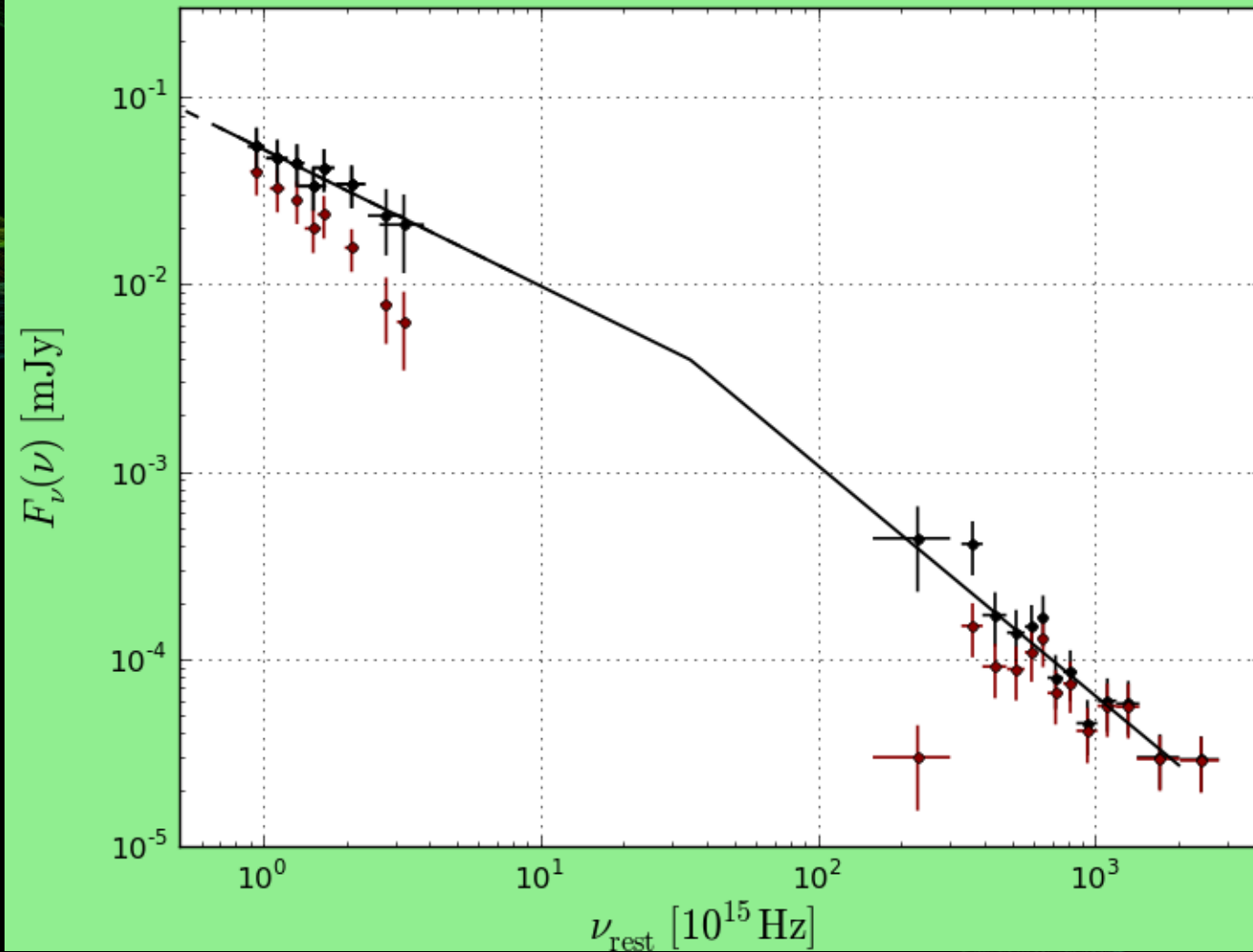


Gomboc et al. 2013 (v pripravi)

# Prve sledi galaksije gostiteljice

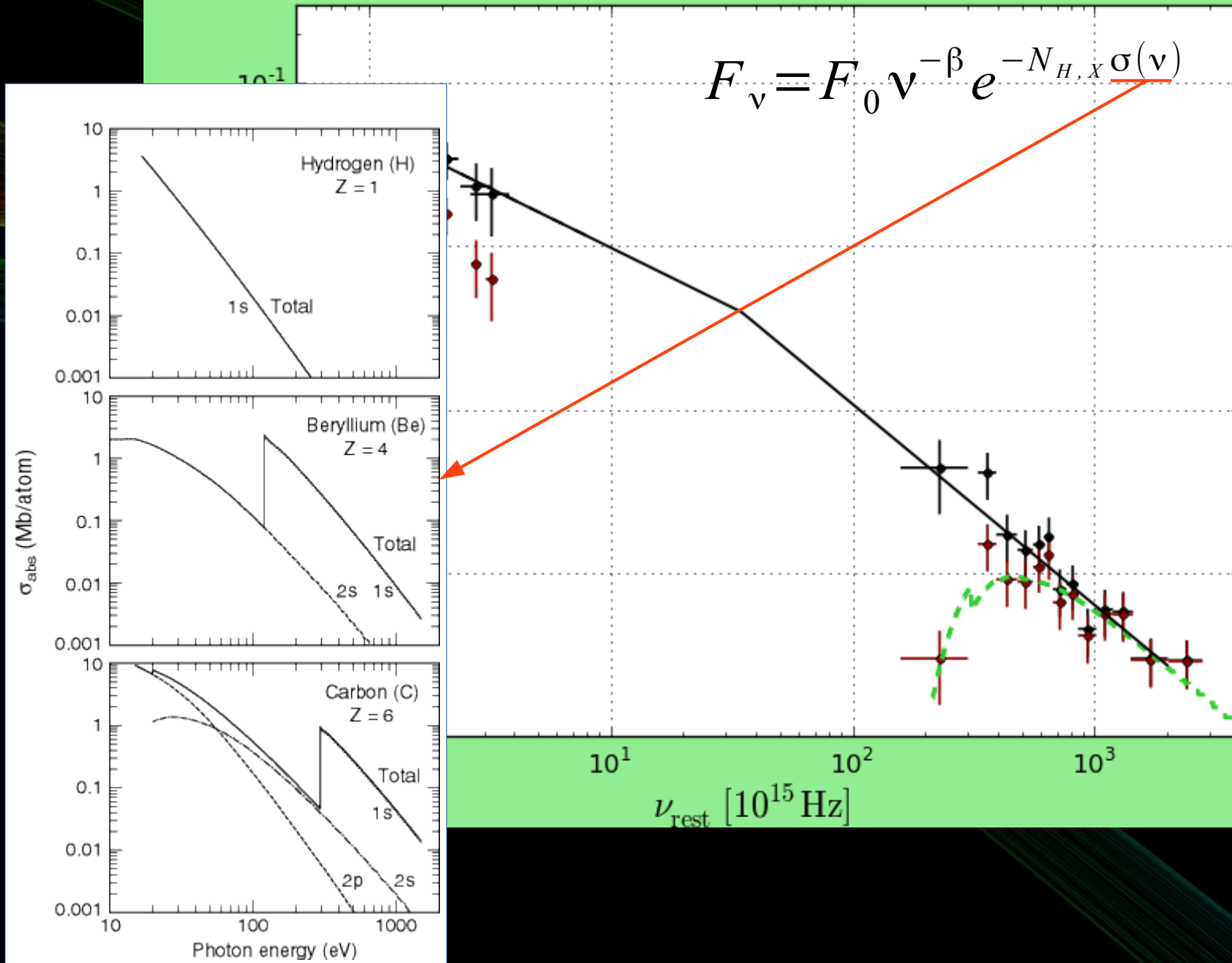


# Prve sledi galaksije gostiteljice

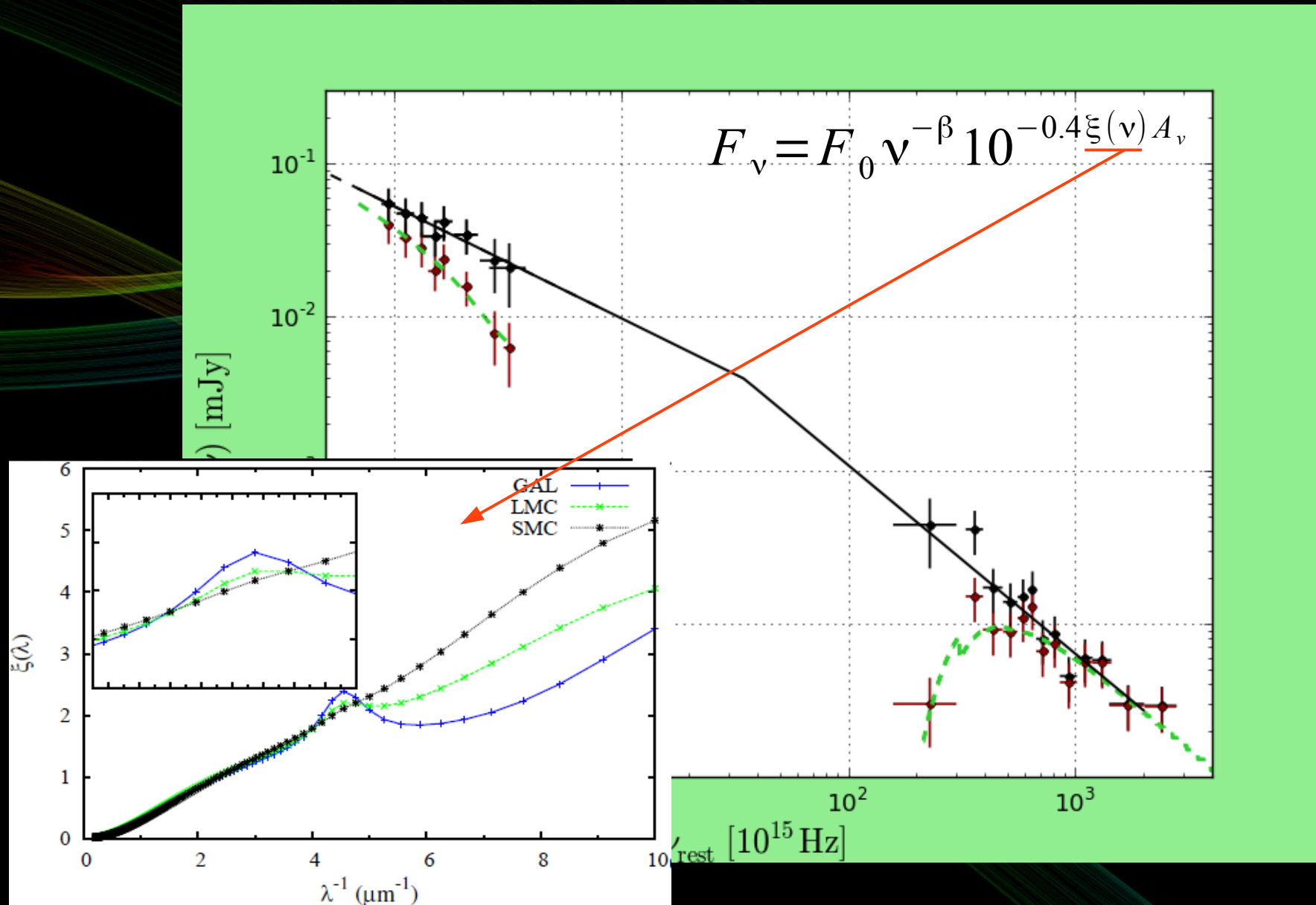


# Prve sledi galaksije gostiteljice

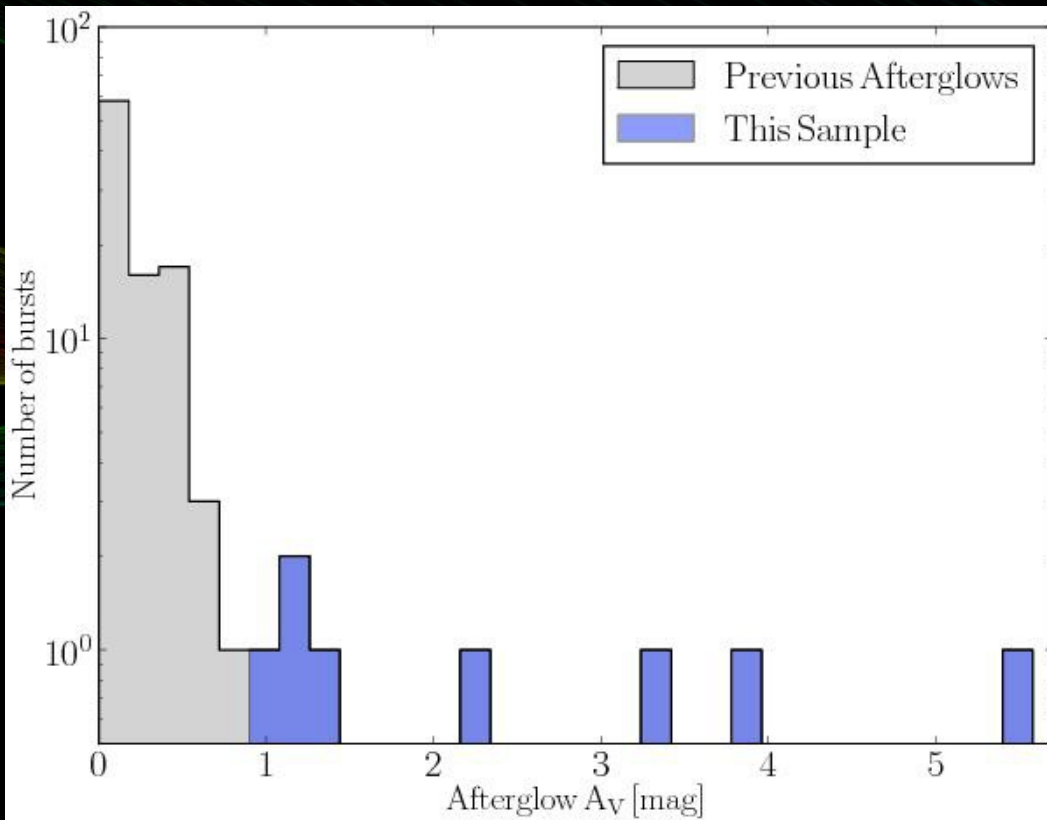
Yeh & Lindau 1985



# Prve sledi galaksije gostiteljice

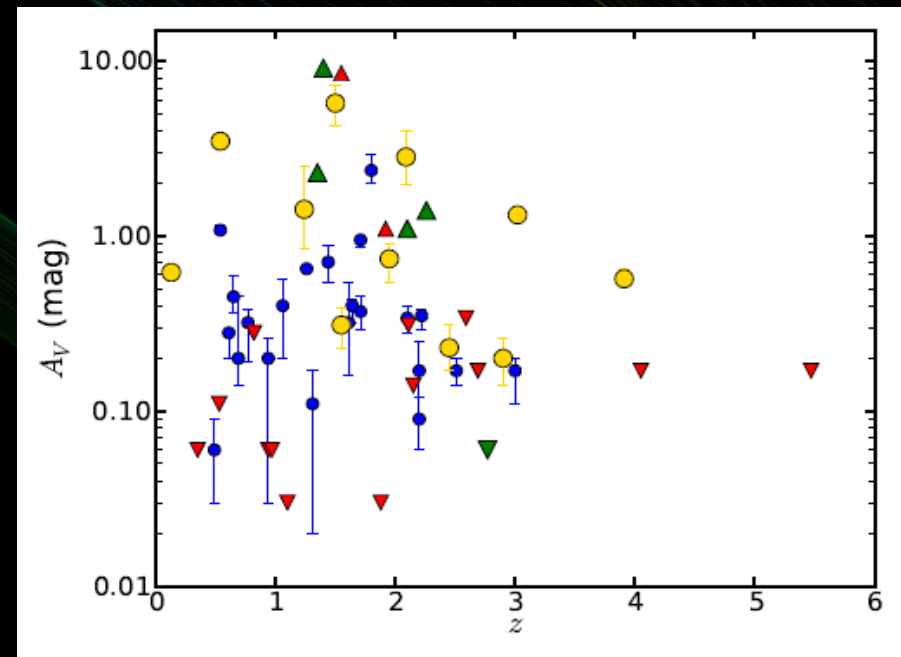


# Statistika I



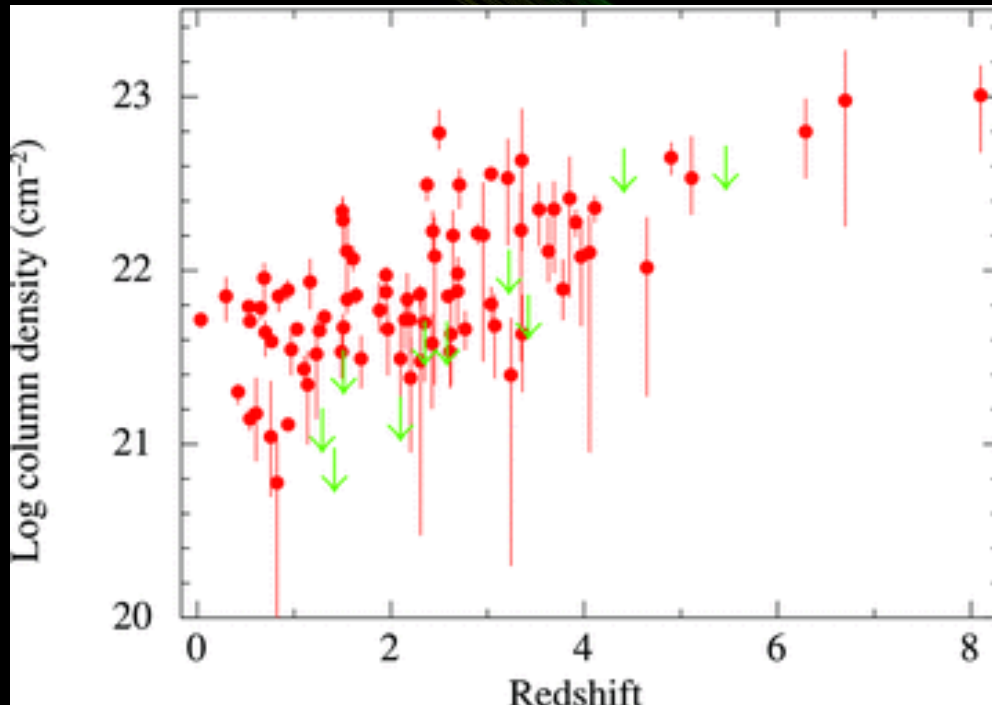
Kruhler et al 2011

$A_V$

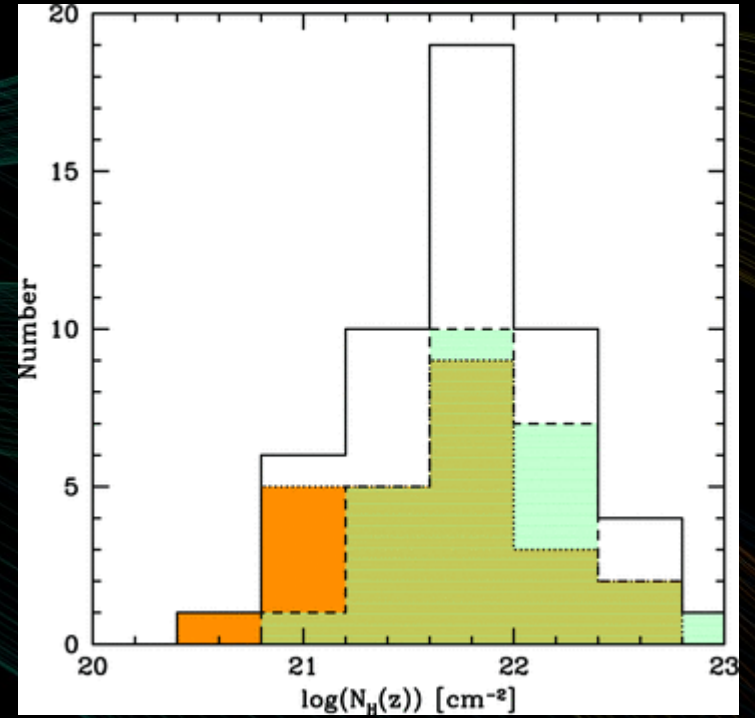


# Statistika I

$$N_{H, X}$$



Campana et al. 2010



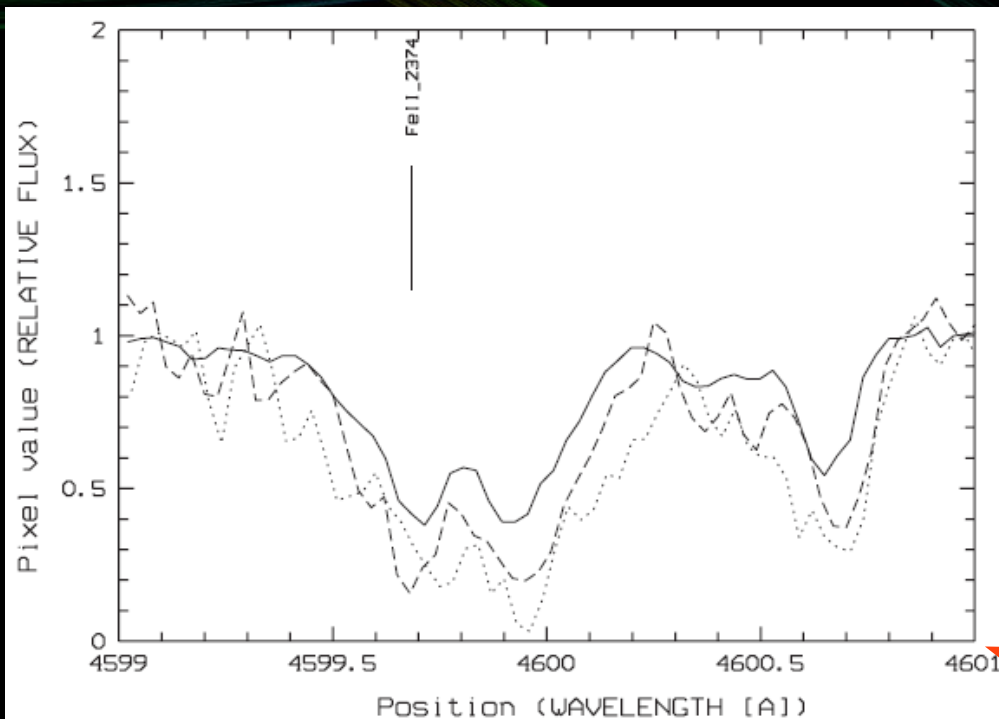
Campana et al 2012

# Bolj podrobno - spektroskopija

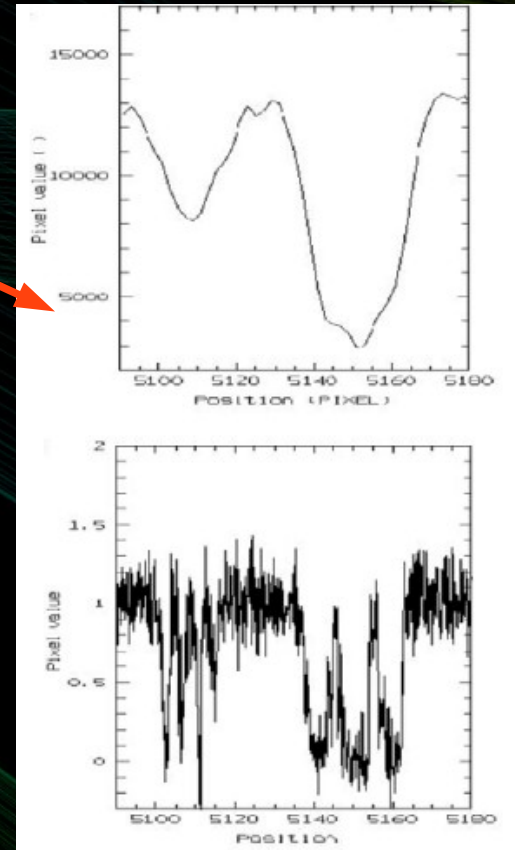
Absorpcijske črte galaksije gostiteljice:  
- kovinskost, kinematika, ekstinkcija, itd.

FORS1 (R=1000) vs UVES (R=40000). Ločljivost!!!

$$R = \frac{\lambda}{\Delta\lambda}$$



D'Elia et al. 2009

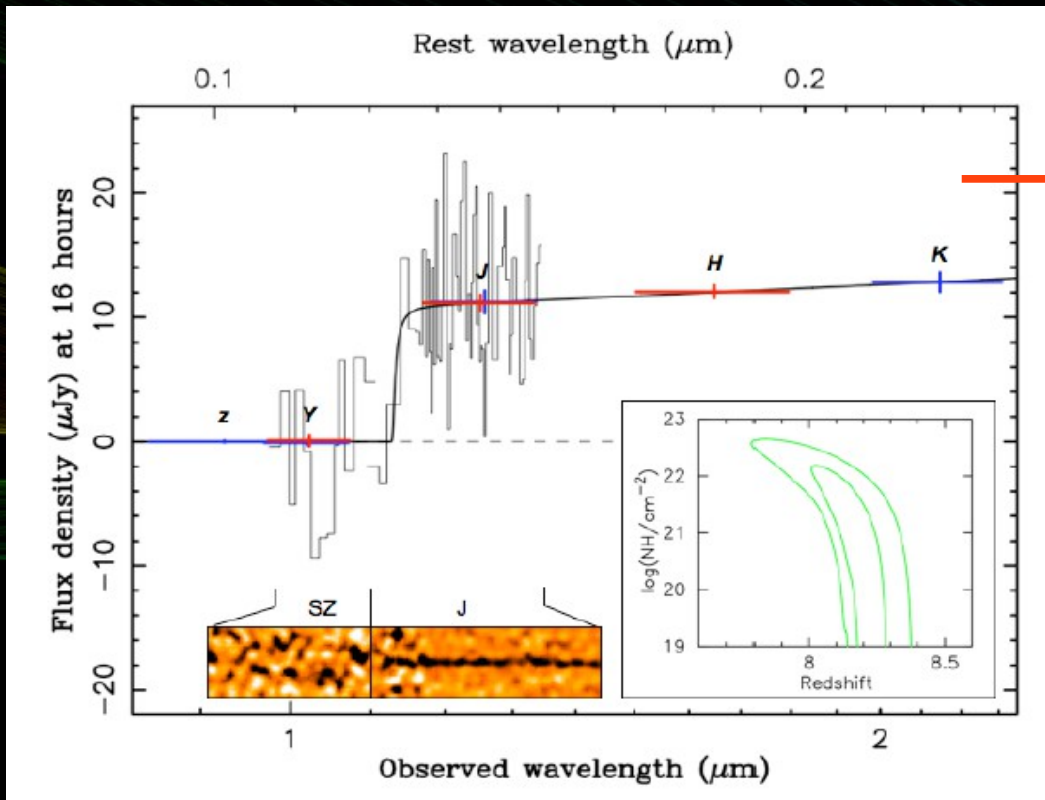


D'Elia 2011

R ~ 100.000



# Kako daleč gremo lahko?



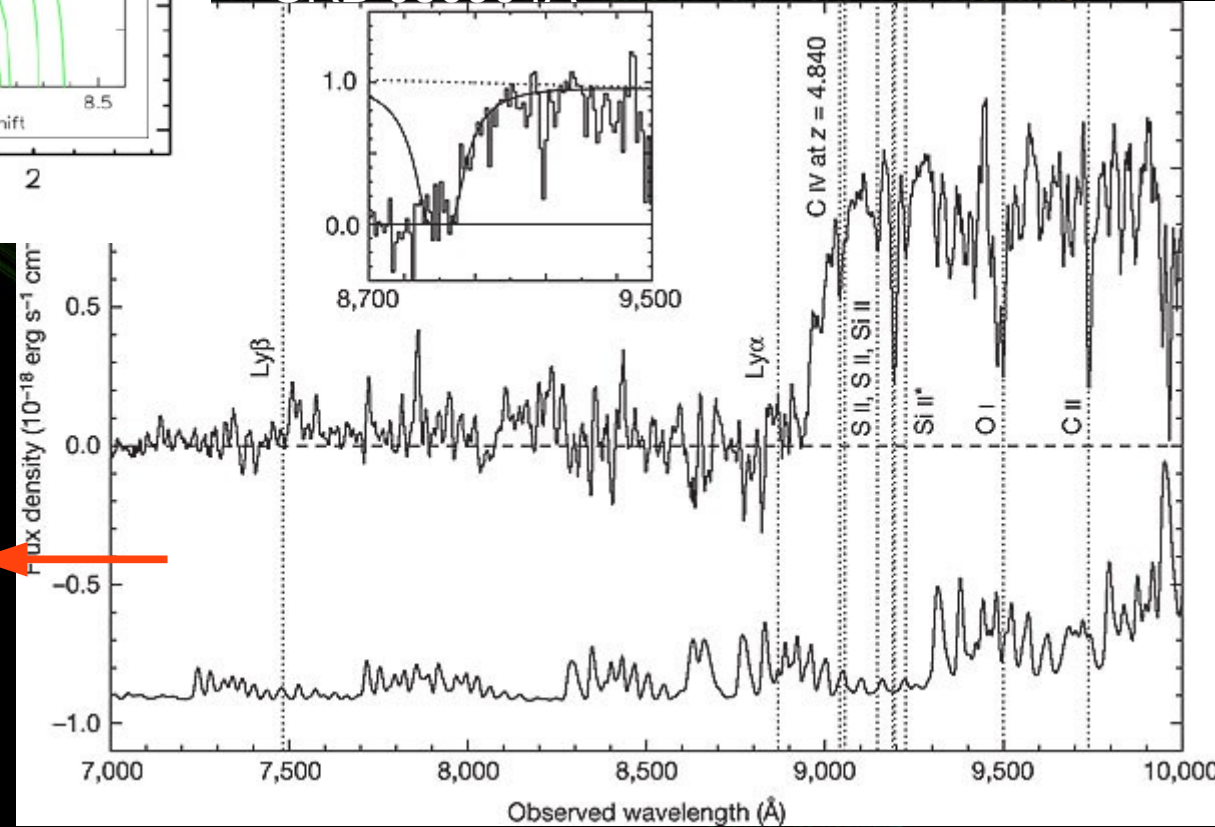
GRB 090423A

$z = 8.3, T = +16 \text{ h}, R = 500$

GRB 050904A

Kawai et al. 2006

Tanvir et al. 2009



$z = 6.3, T = +3.4 \text{ dni}, R = 1000$

NIR območje!!

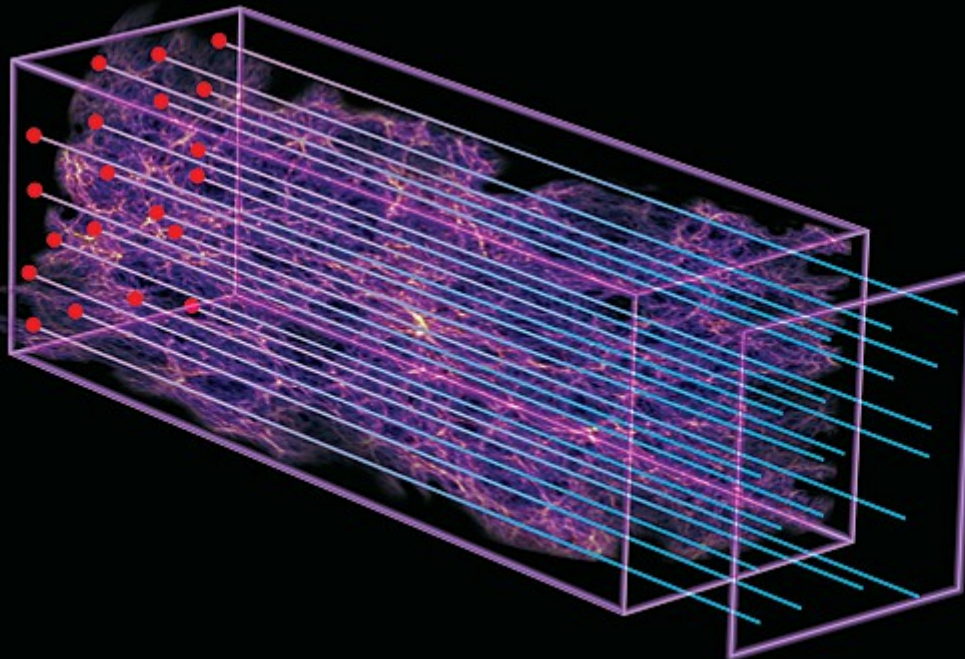
# Kako daleč gremo lahko?

$$1+z = \frac{R_0}{R} = \frac{\lambda_{op}}{\lambda_{em}}$$

$$Ly_{\alpha, m} = 121.6 \text{ nm}$$

$$z = 5.5 \quad Ly_{\alpha, op} = 800 \text{ nm}$$

$$z = 19 \quad Ly_{\alpha, op} = 2500 \text{ nm}$$



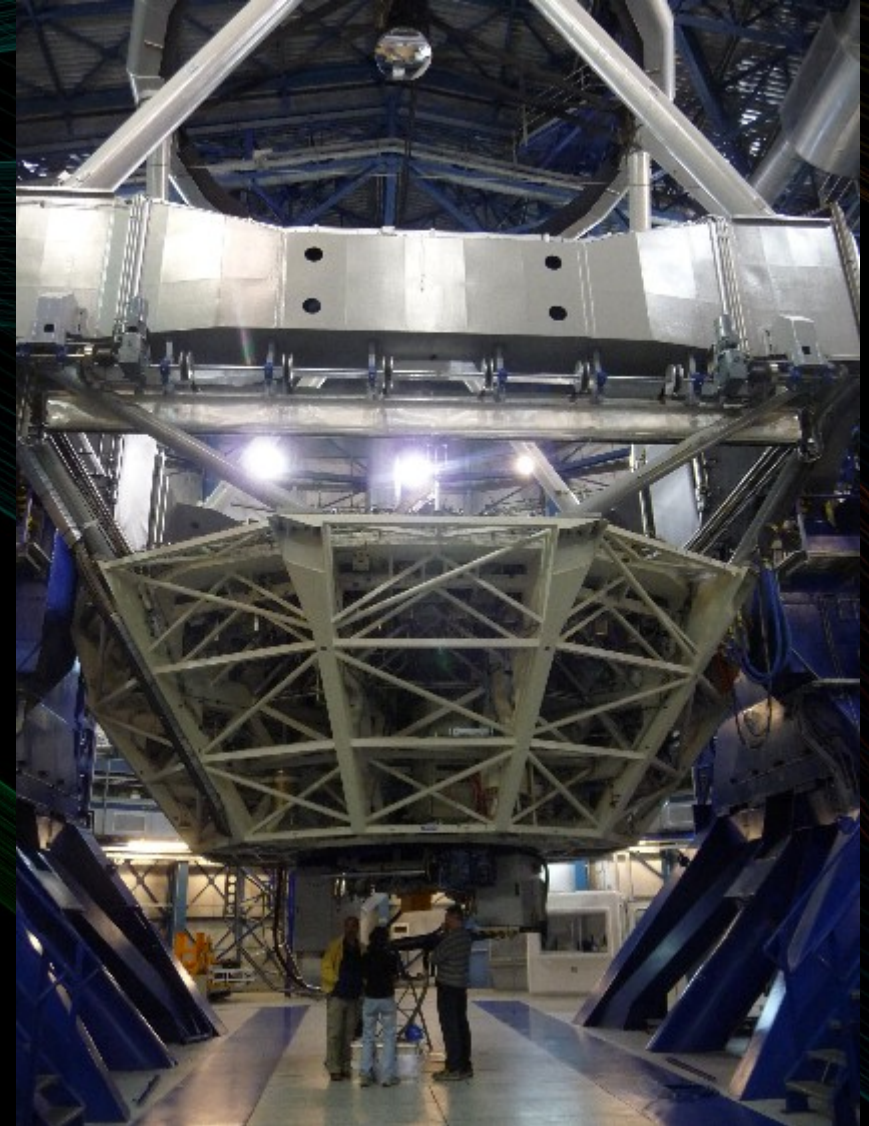
# X-shooter: najbolj vroč instrument



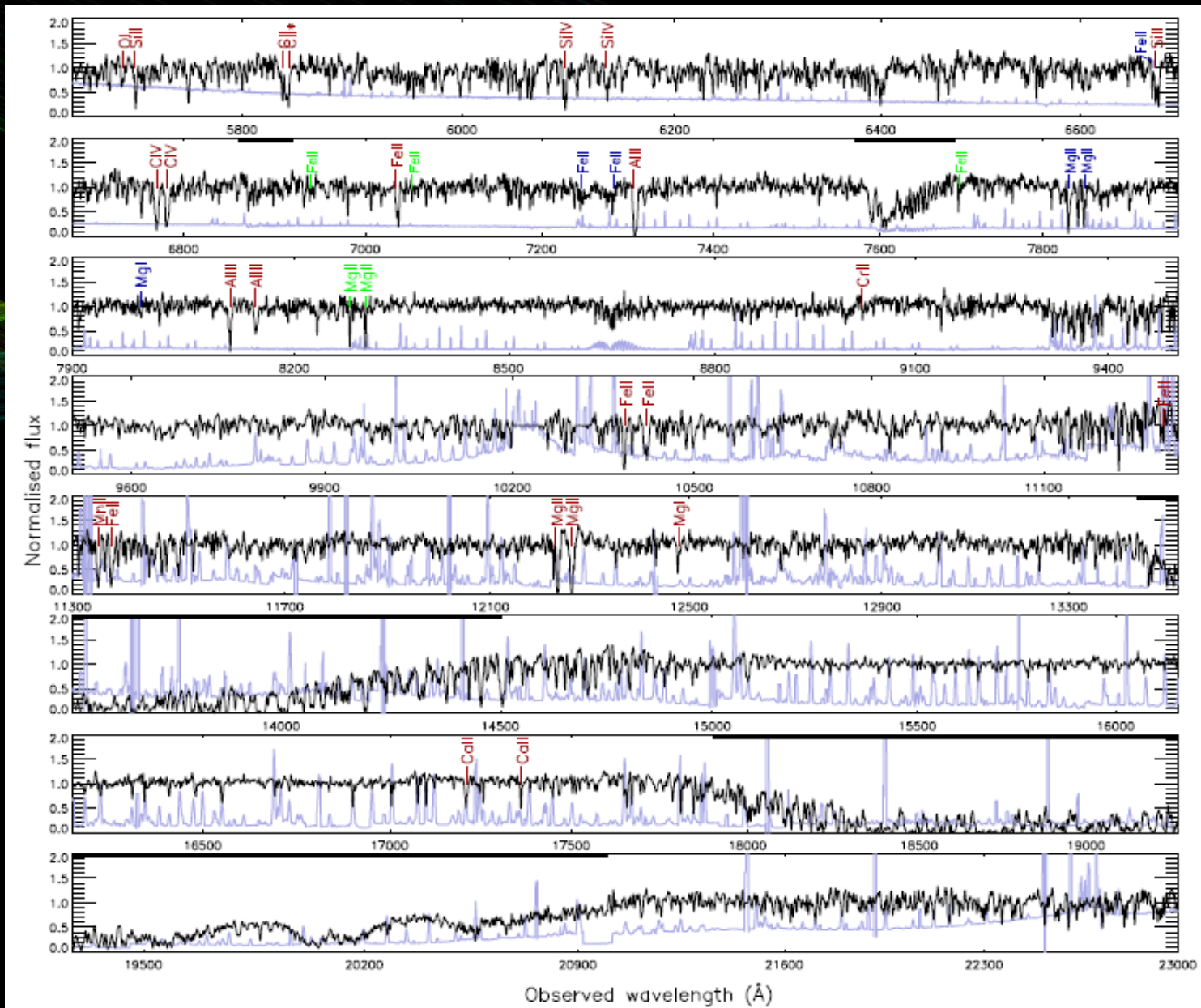
Cerro Paranal, VLT UT2

Široko spektralno okno naenkrat  
300-2500nm!

Srednja ločljivost: R: 7000-12000

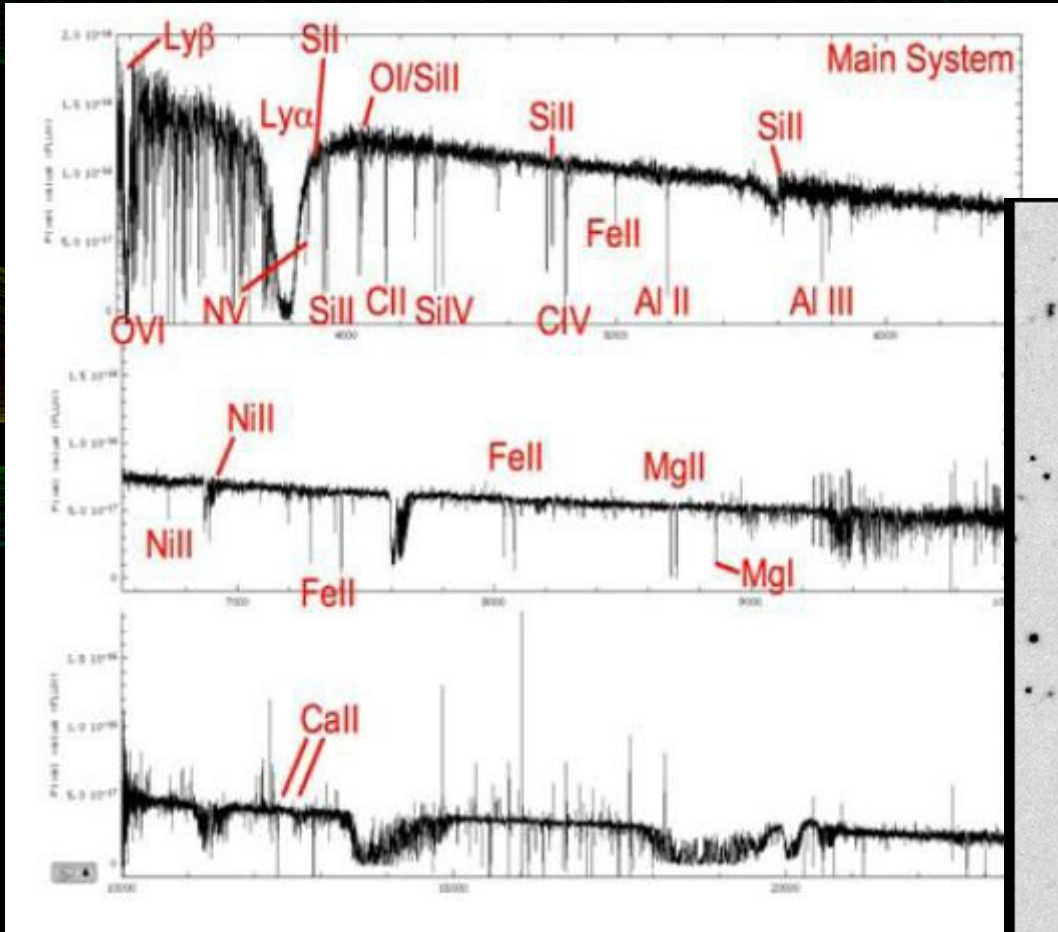


# X-shooter in z=1



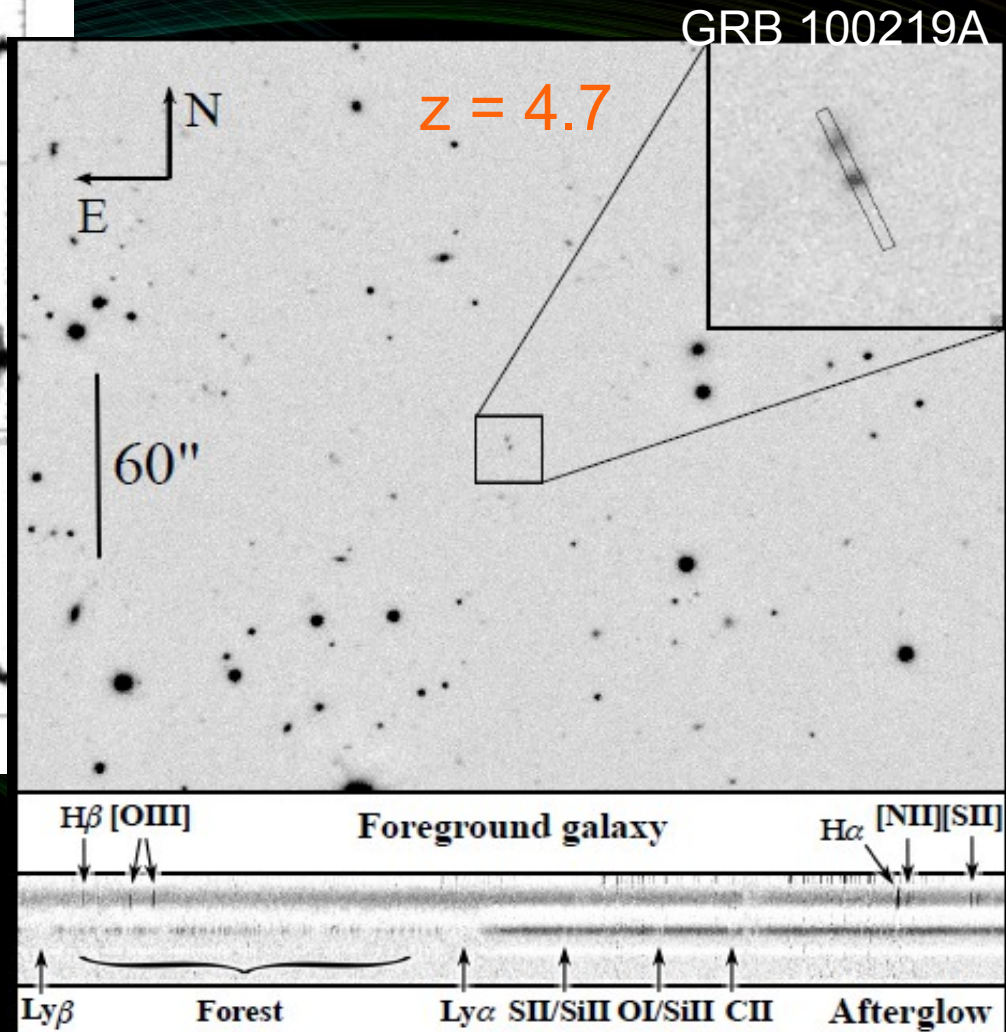
GRB 090313A

# X-shooter in zasilji



D'Elia et al. 2011

GRB 090926A

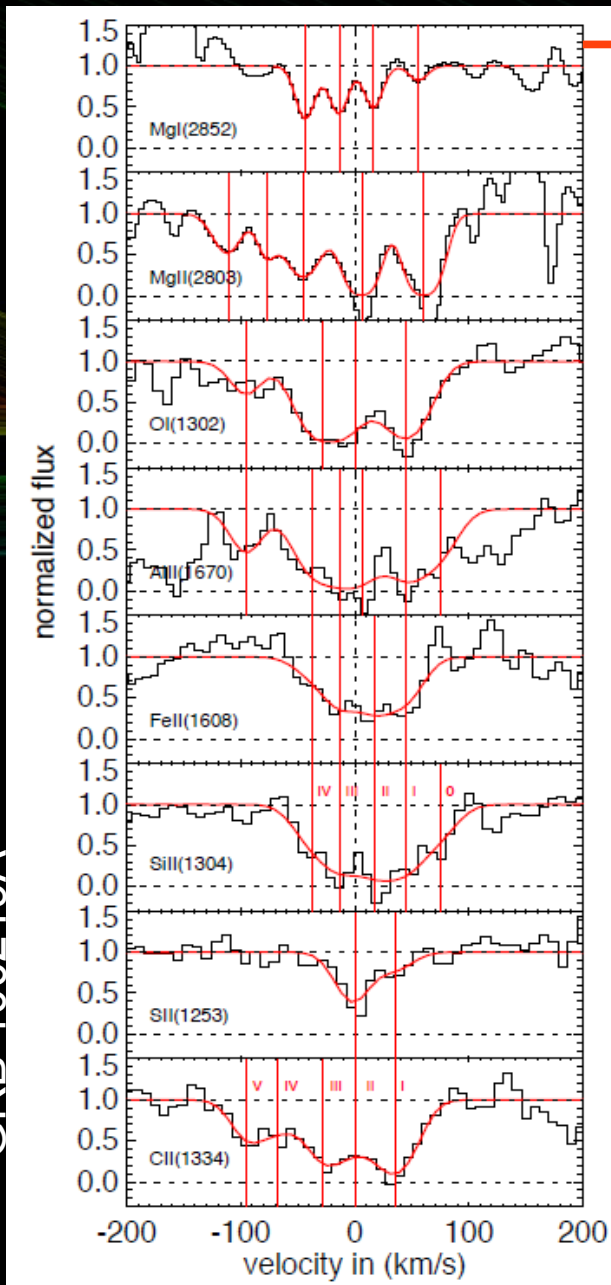


Thone et al. 2012

# X-shooter in zasiji

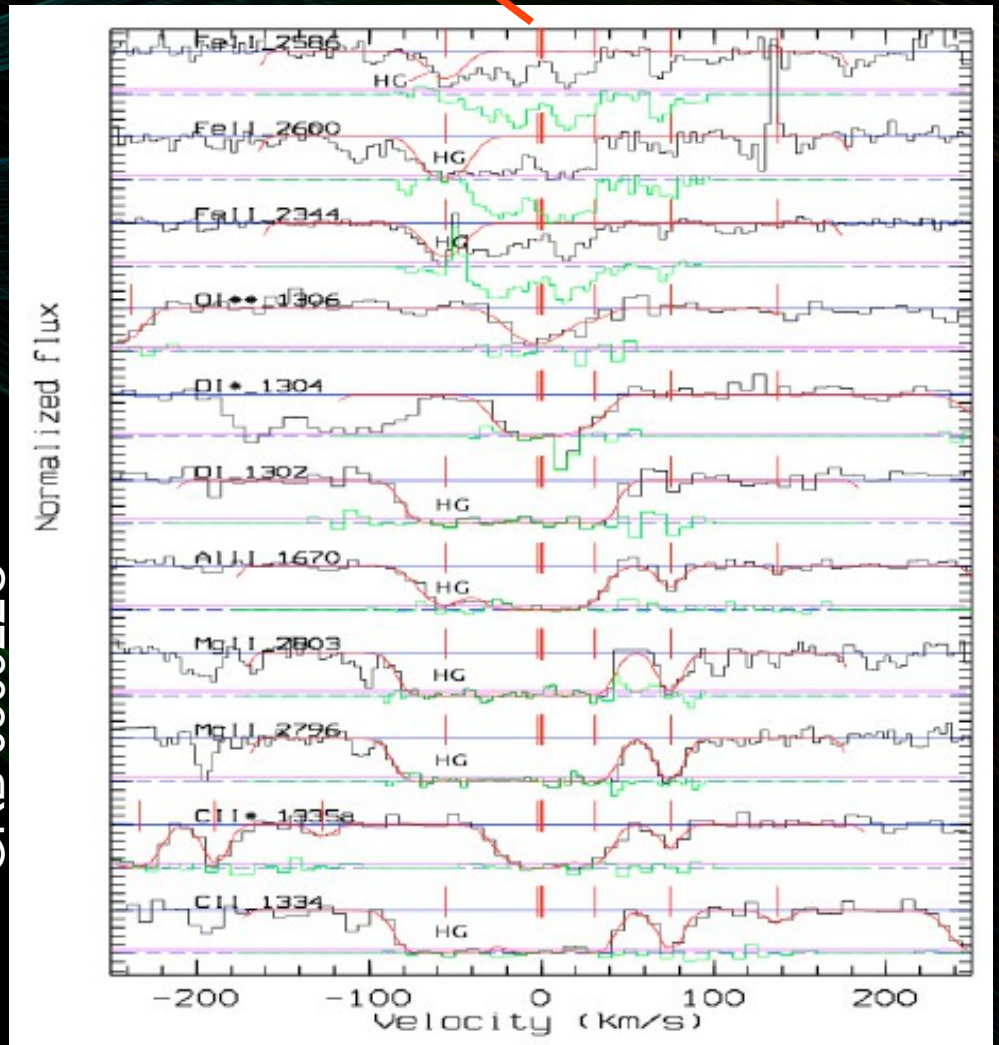
Kompleksen sistem v galaksiji  
gostiteljici

GRB 100219A



Thone et al. 2012

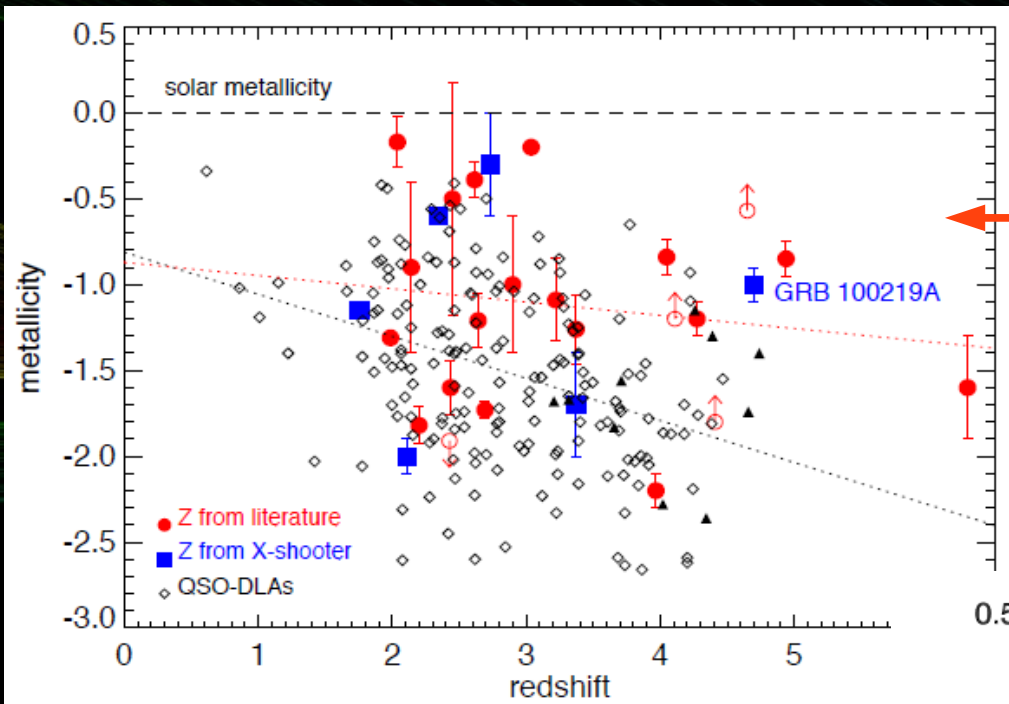
GRB 050922C



Piranomonte et al. 2008

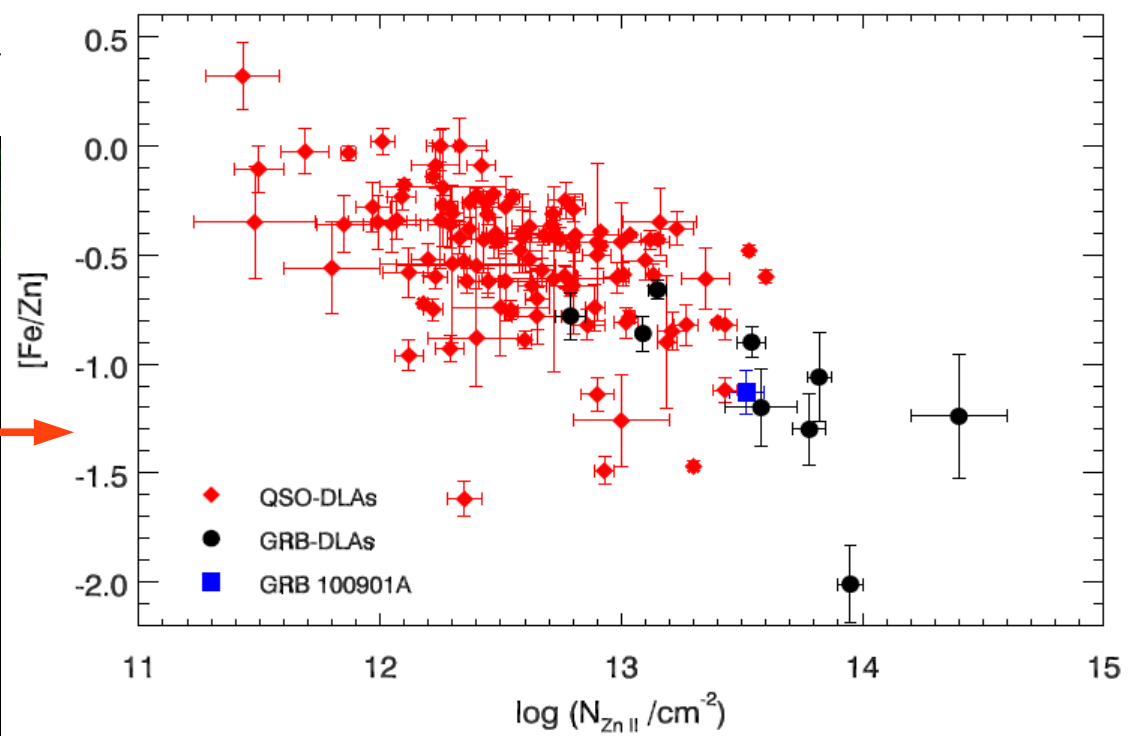
+ več absorpcijskih medgalaktičnih sistemov

# Statistika II



Thone et al. 2012

Plin vs. prah



Kovinskost

Hartoog et al. 2013

# Zaključek

Zasiji predstavljajo velik potencial v raziskovanju mladega vesolja.

Čakamo na svetel zasij oddaljenega izbruha ( $z > 10?$ ).

